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URANIUM HEXAFLUORIDE MANUFACTURE, K-1131 FEED PLANT
PRELIMINARY OPERATING MANUAL
Short Title of Document

PRD-1

D. C. Brater R. C. Olson C. C. Littlefield
B. A. Kress S. H. Smiley
Author

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URANIUM HEXAFLUORIDE MANUFACTURE

K-1131 FEED PLANT

PRELIMINARY OPERATING MANUAL

Date: July 21, 1950 Report No. KDD-207

AUTHORS:

D. C. Brater
B. A. Kress
C. C. Littlefield
R. C. Olson
S. H. Smiley

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I. INTRODUCTION

The Feed Manufacturing Plant, located in Building K-1131, is designed to produce the UF_6 feed for the K-25 - K-27 Diffusion Cascades. In a two-step, continuous process, UO_2 obtained from the Mallinckrodt Chemical Works, is converted to UF_6 at a design rate of 8,000 pounds of UF_6 per day at a 90% operating efficiency.

This report is the operating manual for the above plant and presents in detail: (1) the operating procedures for plant shakedown, plant start-up, normal operations, and plant shutdown; (2) the function and control of all equipment; and (3) equipment specifications and services.

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II. PROCESS TECHNOLOGY

UO_2* is converted in two steps to UF_6. The gaseous UF_6 product is recovered from the gas stream by condensation as a solid and, after transfer as a liquid to feed cylinders, is vaporized to the feed point of the K-25/K-27 diffusion cascade. Figure 1 is the Material Balance Flowsheet. Figures 2 and 3 are the Hydrofluorination and Fluorination Process Flow Diagrams.

The process for manufacturing UF_4 consists of reacting UO_2 with anhydrous HF gas in a vibrating tray reactor. The reaction is reversible** but will proceed to completion if (1) the water vapor formed in the reaction is continuously removed, and (2) the excess HF employed over that theoretically required to effect the conversion is sufficiently large. The UO_2 powder is fed from a hopper by a screw conveyor to the tray and is moved along the tray by controlled vibration. Anhydrous HF gas, preheated to about 1000°F, is fed to the reactor countercurrent to the flow of solid.

The reactor temperature is graded from 750° to 1025°F and the UO_2 powder is kept in the reaction zone for about four hours. Approximately 400 percent excess HF is employed. The UF_4 product is collected in a hopper located below the HF feed point.

The exit gas ($HF + H_2O$) from the tray is cooled to 185°F, partial condensation takes place and a 65 percent by weight HF solution is collected. The uncondensed vapor, which is essentially anhydrous HF, is recirculated by a centrifugal blower. The condensate from the partial condenser drains to a hold tank, from which it is fed to a packed distillation column. The HF solution is rectified in the column to a 98% HF product and a 37% HF waste. The product is returned to the reaction system, and the waste, an azeotropic mixture of HF and water, is drained from the reboiler and discarded. The flow of make-up HF, which is supplied to the system from HF vaporizers located at the fluorine production plant, is controlled by the gas pressure in the mixing chamber.

UF_4 is fluorinated to UF_6 in a vibrating tray reactor identical in principle to the hydrofluorination reactor. The design of this reactor is based on a UF_4 to UF_6 conversion efficiency of 99% at a temperature of 950°F, a fluorine excess of 100 to 150% and a fluorine concentration of 20 to 25 mol percent.

The UF_4 from the product hopper of the hydrofluorination reactor is fed to the fluorination system by a screw conveyor. Fluorine and diluent gases (including some recycled UF_6) are introduced ten feet from the feed end of a thirty foot reactor. The inlet gas is split into two streams, (1) the primary recycle stream, which is about 90% of the total, flows

*Manufactured by the Mallinckrodt Chemical Works from uranium ore.
**MCW Report No. MCW-6.

down the last twenty feet of the reactor concurrent with the flow of solid, and (2) the secondary recycle stream flows up the first ten feet or cleanup section of the reactor countercurrent to the flow of solid. Fifteen to twenty percent of the UF_6 production is accomplished in the ten foot cleanup section and 80-85% in the twenty foot reactor section.

The primary recycle stream containing F_2, UF_6, N_2, O_2, and HF is cooled to 140°F and passed to cold traps where approximately three-fourths of its UF_6 content are condensed out as a solid. The rest of this gas is recycled by a gas compressor. The outlet gas from the cleanup section flows through a particle settler, gas cooler (140°F), and dust filter, to a cold trap where the UF_6 is removed. This gas then flows through an NaF trap to remove HF, and to the fluorine surge tank. A bleed is maintained on this portion of the recycle gas to control O_2 and N_2 concentrations in the system. All the bleed gas is sent through a chemical trap to remove any unreacted fluorine before being exhausted to the atmosphere.

The cold traps employ the existing CO_2 refrigeration system located in K-27. The exit gas temperatures of the main cold traps and cleanup cold trap systems are minus 20°F and minus 30°F respectively.

The UF_6 is liquefied in the cold traps and drained to chlorine cylinders, where the product is weighed and then vaporized to the K-25/K-27 cascade.

III. PLANT LAYOUT

A. Equipment Layout

Figure 4 is a plan view of the west half of Building K-1131 (ground and mezzanine floors) showing the location of the feed plant equipment.

The crane bay which extends the full length of the building between column lines C and D is equipped with a 10-ton overhead crane. The major pieces of process equipment are located in the crane bay between columns 2 and 10. This equipment includes the 40 foot and 30 foot reactors, the feed and ash equipment, the cold traps, and the UF_6 vaporizers.

The electrical load center, the offices, laboratory, and locker rooms are located on the ground floor between column lines D and E and column lines 1 through 8.

The HF and F_2 auxiliary equipment, such as blowers, HF still, mixing chambers, traps, condensers, gas heaters, and coolers, is located on the mezzanine in a 10 foot wide band between columns 2 and 7 along column line D. The vacuum pump, filter, and CO_2 surge drums and heat exchangers are located along the front edge of the mezzanine between columns 8 and 10. The control room is also on the mezzanine, between column lines D½ and E extending between column lines 7 and 12 (only partially shown).

The fluorine plant equipment, which is also in Building K-1131, is described in the Fluorine Plant Operating Manual*.

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* "Preliminary Operating Procedure for K-1131 Fluorine Manufacturing Plant", June 14, 1950; C. B. Clifford, et al.

B. Heating and Ventilation

The heating and ventilation systems are classified as normal heating, normal ventilation, and special ventilation systems.

1. Normal Heating System

The normal heating system consists of units supplying heat to the crane bay and mezzanine, the control room, and the locker room.

Heat for the crane bay and mezzanine is supplied by four unit heaters, floor-mounted against the north wall of the building along column line C between columns 2 and 3, 7 and 8, 12 and 13, and 17 and 18. These units are capable of supplying 18,250 cfm of 85°F air each. The push button stations for these units are mounted locally on columns 3, 8, 13 and 18.

Heat for the control room is supplied by a unit heater with a capacity of 5,500 cfm at 70°F. The heater is located between columns 11 and 12, about half way between column lines D½ and E. The push button station is on the outside of the east wall of the control room, beside the control room door. The heated air supplied to the control room is exhausted through wall louvres to the mezzanine.

Heat for the locker rooms is supplied by a unit heater mounted on the wall of the cold locker room at column 5 on column line D½. This heater has a capacity of 2860 cfm air at 70°F. The push button is located near the door on the wall on column line D between columns 4 and 5.

2. Normal Ventilation System

The crane bay and mezzanine are ventilated by a 23,000 cfm exhaust fan which removes the air from various points along the mezzanine through openings in a duct and discharges it to an eighty foot stack. This fan is located on the mezzanine near column 14 between column lines D½ and E. The push button is mounted locally, adjacent to the motor.

Ventilation is supplied to the control room by three 4000 cfm fans mounted in the windows in the south wall on column line E near columns 8, 10, and 11. The push buttons for each fan are mounted on the column next to the fan. A slightly positive pressure is maintained in the control room to prevent fouling of the control room air supply in the event of a process break.

Ventilation for the locker room consists of metal ducts at each end of the room connected to short stacks that protrude through the building roof.

The electrical distribution room has a small exhaust fan mounted in the west wall of the building near column D½ on column line 1. The inlet air to the room enters through louvres in the door.

3. Special Ventilation

Two separate systems have been provided in the feed plant for special ventilation. One system is for contaminated dust handling, the other is for corrosive gases.

a. Dust System

A vacuum conveying system for dust collection has been installed with outlets provided at points where powder may be exposed. The dry box on the ground floor on column lines 2 and C$\frac{1}{2}$ is connected permanently to this system. All other outlets are equipped with hose connections, and are capped when not in use. The vacuum cleaner is located on the mezzanine against the south wall of the building between columns 4 and 5. The cleaner is equipped with a multiple bag filter which may be emptied into a dust-tight can by a simple lever operation. The discharge from the cleaner is connected to the exhaust duct on the mezzanine, which goes to the normal ventilation stack. One push button station for the cleaner is mounted locally, near the motor, and another is mounted on the ground floor at column D-4.

A more detailed description of the dust removal system is presented in the Solids Flow System.

b. Emergency Ventilation

The three UF_6 vaporizer hoods located in the cold trap area, are connected through a duct to a fume scrubber located on column line 10 at the west end of the cold traps on the ground floor. A blower on the mezzanine near column 10 on column line D acts as an ejector for this system, discharging upward through the roof. Since this unit is to be operated in an emergency when a material release occurs at the vaporizers, there are three push button stations. One station is located at each end of the cold trap supporting frame and one in the control room on the electrical panel.

C. Electrical Layout For Feed Plant (Figure 5)

The main power supply to the feed plant comes from Building K-1231 through an oil circuit breaker to Transformer "C" (1000 KVA, 13.8 KV/440 V.) located outside at the southwest corner of K-1131. The switchgear cubicle is located in the main distribution room on the southwest side of the building. The switchgear contains nine (9) circuit breakers:

1. The main breaker (1D) from the secondary side of the transformer;

2. Three breakers (2D, 3D, 1E) for the screw and reactor furnaces;

3. Three breakers (2E, 3E, 2F) for three load centers located in the power room;

4. One breaker (1F) for the load center located in the cold trap area;

5. Spare breaker (3F).

1. Breaker 1D (Figure 6)

Breaker 1D is the main breaker to the Feed Plant and feeds the bus in the switchgear unit. There is one 1500/5 current transformer and one 420/120 volt potential transformer on this bus with terminal blocks for portable meter tests.

2. Breakers 2D, 3D, 1E (Figure 6)

The circuits from breakers 2D, 3D and 1E are identical and the following description is typical for each circuit:

Individual tap-offs from breaker 2D are made to one 130 KVA transformer, type 32 IR6-2C, 60 cycle, 3/2 phase, voltage 480/460/440 to 120/60, which is tied into the contactor for one hydrofluorination reactor furnace, and one 90 KVA transformer of the same type, which is tied into the contactor for one fluorination reactor furnace. The 130 KVA transformer also supplies power to the UO_2 screw feeder furnace.

In the 130 KVA transformer circuit all the heating elements in the lower halves of the furnace sections are connected through individual contactors to one phase of the 2 phase secondary and all elements in the upper halves of the furnace sections are connected to the other phase, also through individual contactors. Each secondary phase of the transformer is provided with a separate 6 point tap switch so that voltage applied to either top or bottom heating elements can be reduced from a maximum of 120 volts to 60 volts.

The 16 contactors (Allen-Bradley, Type 702, Magnetic Contactor, 90 amp, 2 pole, 120 V. with a 110 V. 60 cycle holding coil) for the eight furnace sections and the contactors for the UO_2 screw feeder furnace are located in the back side of the case holding the transformer.

The contactors in top or bottom of each zone of the furnace are energized by temperature indicating controllers (located in the control room).

Power to the coils in the contactors is supplied by a 3 KVA control transformer, 460/120 V., 60 cycle, 1 phase, also located in the rear of the transformer case.

The 12 furnace contactors in the 90 KVA transformer case are identical in operation to those in the larger transformer case. In both transformer cases a single push button is used to supply power to the 3 KVA control transformer and is used for turning the entire furnace on or off by energizing or de-energizing the contactor coils.

The cables from the transformers in the distribution room are carried to the mezzanine through sheet metal ducts and then in transite trays either to the points where they enter conduits running to the reactors or to the control room where the controllers are located. The cables for all three hydrofluorination reactors are placed in fifteen 3" conduits which run from the transite trays on the mezzanine, down the wall behind the crane rail, and across the room under the floor to each reactor. The conduits come up through the floor to each reactor and the cables are then carried to each section of the reactor furnace and the screw feeder furnace through sheet metal boxes mounted on the reactor base framework.

The cables for the fluorination reactors are carried in nine 3" conduits running down the wall and under the floor in the manner described above. The sheet metal boxes carrying the cables to the individual furnace sections are placed on the floor alongside each reactor.

In addition to the conduits for the power cables, one 3" conduit runs between each reactor and the control room for lead wires connecting thermocouples in the furnaces to the temperature controllers and recorders.

3. <u>Breaker 2E</u> (Figures 6 and 7)

Breaker 2E feeds the load center 2E which is located in the distribution room. This load center contains branch breakers for the following items of equipment:

NaF Trap Heaters
HF Still Heaters and Column Heaters
HF Gas Recycle Blower Motors
Fluorination Reactor Motors
UF_4 Screw Feeder Motors
HF Superheater and Preheaters
Ash Receivers and Dust Filter Heaters.

For the HF still heaters, a 50 KVA, 440-208/120 V., 3 phase, transformer is provided so that the still can be operated at different capacities depending on the number of reactor lines in operation. Manual controls in the control room permit the use of 30 KW, 45 KW, or 60 KW heat input to the still. The main disconnect switch is located on Panel 2E.

Since the temperatures of all equipment to be heated are controlled either locally or from the control room, all circuits feeding the heaters on these items have 480/120 V., 1 phase, control transformers mounted near the corresponding circuit breakers to supply 110 volt current to the relay coils energized by the controlling instruments.

Start and stop manual control buttons for the various motors fed by the breakers on 2E are located at each motor with emergency buttons and indicating lights in the control room.

The cables supplying power to the vibrator and screw motors are run from the distribution room to the motors in trays and in conduits placed alongside those carrying the cables to the reactor furnaces.

4. <u>Breaker 3E</u> (Figures 6 and 7)

Breaker 3E feeds load center 3E which is located in the power room. This load center contains branch breakers for the following items of equipment:

Distribution Room Fan Motor
Vacuum Cleaner Motor
Unit Heaters
440 V. Receptacles in Feed Plant
Primary and Secondary Gas Blower Motors
NaF Traps
Hydrofluorination Reactor Motors
UO_2 Screw Feeder Motors

Similarly to Panel 2E, all necessary control transformers to supply 120 V. power to relay coils and contactors for the screw and reactor motors are located on Panel 3E.

The contactors for the motor starters on the vibrators and screws are on the panel, the timing mechanisms, emergency stop buttons, and indicating lights are in the control room, and normal start and stop buttons for all motors are mounted locally near each unit.

5. Breaker 1F (Figures 6 and 7)

Breaker 1F feeds the load center 1F which is located in the cold trap area near column 8.

The loads on this feeder are:

Cold Trap Control Panels
UF_6 Vaporizer Heaters
Vent Fan for Vaporizers
Scrubber Motor
Vacuum Pump
Vaporizer Heater Fans
Pipe Heating, Cold Trap Area only.

Power is supplied from a main switch, 460 V., 3 phase, on the load center, to nine individual cold trap heater control boards located under the cold trap platform. Each control board contains the relays, switches, alarms and transformers for regulating heaters on one cold trap and adjacent piping.

An "on" - "off" push button is supplied for each cold trap heater so that, if desired, individual heater control may be maintained. Indicating series lights are installed in the wires to each of the heaters in the cold trap inner and outer heating circuits to show whether the heaters are operating.

All heaters with "on" and "off" control are fed through normally closed relay contact set to open on increasing temperature. A multipoint temperature recorder controller constantly scans all portions of the cold traps being heated, and if an abnormally high temperature reading is obtained the relay coil is energized, de-energizing all heaters on the cold trap and sounding an alarm. The alarm has a silence button and the heater circuits must be manually reset before they will again be energized.

The outlet, insertion, and nozzle heaters are controlled by variacs and switches.

Indicating lights on the panel boards and in the control room show high temperature, high pressure, or low flow in any cold trap.

Power is supplied to the vaporizer heaters and fans from three main breakers on load center 1F. The push buttons for "on" and "off" control of these motors and heaters are mounted locally near each vaporizer. The circuits are interlocked with temperature, pressure and flow controls to prevent excessive UF_6 pressure build-up in the vaporizers. Indicating lights mounted locally show whether motors and heaters are energized.

The vent fan motor and scrubber motor are interlocked so that if a leak occurs around a vaporizer and the vent fan is turned on, the scrubber motor will start to pump water through the UF_6 removal system in the stack. Three separate push button stations with indicating lights are supplied for these two motors.

The pipe and pipe casing heaters in the cold trap area are supplied through a 25 KVA, 460/208/120 V. transformer located at the load center. Power is fed from the transformer through a series of relays and mercoid control stations to all piping to be heated.

The relays are mounted on the individual cold trap control boards while the mercoid control stations are located around the area adjacent to the section of pipe heaters being controlled.

C&CCD Drawing AWE-17202 shows the location of each of the mercoid control stations in the cold trap area.

6. Breaker 2F (Figures 6 and 7)

This breaker feeds load center 2F through a 150 KVA, 460/208/120 V., 3 phase, transformer. The transformer and load center are in the Distribution Room. Branch breakers are provided for the following:

Pipe Heating Panels A, B and C
Fluorine Analyzer.

A fluorine analyzer utility panel is located on the mezzanine floor between columns 5 and 6. Power from the breaker on the load center is supplied to this panel for use in the analyzer equipment.

The pipe heater panels are located on the mezzanine floor as follows:

"A" - Column 4
"B" - Column 7
"C" - Column 8.

Each heating panel contains a series of switches which supply power to the various heating circuits. Each circuit is further divided up into one, two or three control circuits, each of which has a mercoid control station located near the heaters being controlled. Each control station has one, two, three, or four mercoid switches.

The heaters connected to Panel "A" are located mainly between column lines 1 and 6 on the mezzanine and ground floor; those connected to Panel "B" are between column lines 6 and 8 on both floors; and the heaters from Panel "C" are located between column lines 5 and 12. Drawings AWE-12580, 12591, 12592, 12593, 12594 and 12595 show the actual location of all the mercoid control stations for the three different panel circuits.

D. Instrument Panels

1. Control Room Panels

The control room has a total of thirteen panels pertaining to the feed plant. Starting on the west side of the room, the first panel contains three TR's - 1052, 1053 and 1054. These instruments are 16-point Micromaxes and record the temperatures of the various bottom sections of the hydrofluorination and fluorination reactors.

The next five panels have a total of 48 TIC's which control: a.) the temperature of the top and bottom halves of each heating zone on the hydrofluorination and fluorination reactors; b.) the temperature of each of the three UO_2 screw feeders; c.) the temperature of each of the HF preheaters. Individual stop buttons are provided to shut off the power to the heaters in each zone of each reactor furnace, the UO_2 screw feeder furnaces, and the HF preheaters.

The seventh panel in line contains the following instruments:

1. Three 0-20 minute Flexopulse Timers, one for each hydrofluorination line.
2. Three 0-30 second start delay relays, one for each hydrofluorination line.
3. Three 0-30 second stop delay relays, one for each hydrofluorination line.
4. Twelve indicating lights, one for each screw and reactor motor.
5. An emergency stop button for each of the six lines of equipment.
6. Start and stop buttons and indicating lights for the vaporizer vent fan.
7. On and off buttons for the HF superheater.
8. Two selector switches for the HF reboiler heaters.
9. On and off buttons for the top heaters on the HF still column.
10. On and off buttons for the bottom heaters on the HF still column.

Panels eight through twelve comprise the Graphic Panel Board for the feed plant. Figure 8 in the appendix shows this board together with the reference numbers and locations of the instruments.

The graphic panel board gives an overall picture of the feed plant operation at all times.

The solids weight recorders and high and low level alarms show the flow of solids, UO_2 to UF_4, (hydrofluorination) and UF_4 to UF_6 (fluorination) through the reactors to the ash receivers. Temperature indicating and recording controllers on the panel show the heating conditions of the reactors.

The flow and control of HF and F_2 to and from the reactors is shown by pressure recording controllers, pressure indicators, and flow recorders and controllers, together with alarm lights and pump motor indicating lights. As indicated in Figure 8, these instruments are mounted with appropriate flow lines to indicate graphically their function in the plant.

In a similar way, the HF recirculation system, the cold trap system for UF_6 removal, and the F_2 recirculation system are all shown in their relative positions on the panel with appropriate recorders, indicators, controllers and alarm lights so that the operation of any individual unit in the system may be observed at any time.

The thirteenth panel for the feed plant has TI-487 which indicates the following temperatures:

1. Gas temperatures on inlet and outlet of hydrofluorination reactors (H-6A, B and C).

2. Outlet temperature from gas coolers (F-7A, B and C).

3. Temperature of HF going to mixing drum (H-4).

4. Gas on outlet of fluorination reactors (F-2A, B and C).

5. Gas outlet from NaF traps on HF and F_2 systems (H-13A, B and F-10A and B).

6. Gas outlet from F_2 mixing chamber (F-1).

7. Gas outlet from HF superheater (H-3).

Also, on this panel are a.) the flow recorder (FR-149) which records the amount of fluorine coming from the fluorine plant into the mixing chamber (F-1), b.) an indicating light to show that the alarm circuit is supplied with power, and c.) a push button to silence the audible alarm after it has sounded.

2. <u>Cold Trap Area</u>

There are a total of eleven panels located under the cold trap supports near the south wall of the feed plant room. Nine of the panels are electrical control panels, one for each cold trap, and they contain the necessary PBS's (pressure blind switches), on-off buttons, relays, transformers and circuit breakers for operating the cold trap and piping heaters in that area. In addition to these electrical controls, each panel has for its cold trap, the high pressure, high temperature, and low flow alarms and the pressure indicators showing trap pressure during the heating cycle and gas flow from the trap during the freeze-out cycle.

Those PBS's controlling the heaters on the cold traps and those actuating the AI's (indicating alarms) through the flow elements on the gas outlets are located on the rear of these panels.

The tenth panel in the area contains three temperature recorder controllers - TRC-339, 355 and 371. Each of the first two TRC's controls three of the primary cold traps and the third controls the secondary cold traps.

The eleventh panel in this area is for the UF_6 vaporizers and has the following instruments:

1. PRC-911, 912 and 913 which control and record the flow of UF_6 to the cascade.

2. AI-999, 1000 and 1001 which indicate excessive pressure in the feed line from the vaporizers.

3. AI-1058, 1059 and 1060 which indicate excessive pressure in the vaporizer.

PBS's for controlling the heaters and fans on the vaporizer units are located on the rear of this panel.

3. Solids System Area

Five instrument panels are located in the reactor area. The main function of the panels is to provide instrumentation for the bellows buffering system, and is discussed in section IV of this report.

However, in addition to the buffer system instrumentation, the three panels near the UF_4 feed hoppers also contain a.) PI's 766, 786 and 806, which indicate the pressure in the HF reactors, b.) PI's 836, 853 and 870 which indicate the pressure in the fluorine inlet lines to the fluorination reactors, and c.) the PBS's which actuate the high and low tray pressure alarms located in the control room.

The buffer system panel near the ash receiver pit has PI's 830, 847 and 864 which indicate the pressure in secondary recycle lines at the exit of the fluorination reactors.

4. Refrigeration Instrument System

One panel board is located on the mezzanine floor between the two CO_2 surge drums. It has the following instruments:

1. Two level indicators for the surge drums.

2. Six alarm lights to indicate low, intermediate high, and high level in either surge drum.

3. Two pressure indicators to show the pressure in both surge drums.

On the rear of the panel are mounted the two transmitters which actuate the level indicators and the six PBS's which actuate the level alarms.

5. Seal Feed System for F_2 and HF Blowers

Two panels are located on the mezzanine near their respective sets of blowers. The panel for the HF blowers has a PI to indicate the flow of nitrogen or dry air to the seal, a PI to show the seal feed pressure, an alarm for high flow, and two transfer cocks for switching the seal feed instrumentation to the particular pump in operation. The flow element, pressure transmitter, and mercoid switch to actuate the alarm are mounted on the rear of the panel. The panel for the F_2 blowers contains two individual sets of instruments, one for the primary and the other for the secondary blowers.

Each of the four Roots-Connersville blowers has four seals; and two sets of eight transfer cocks are required to switch the instruments to the particular blowers in operation.

IV. FLOW AND CONTROL

A. Solids Flow System (Figure 9)

1. Powder Flow

UO_2 powder, as received, is unloaded from the thirty gallon shipping drums into the UO_2 feed hoppers (H-17A, B, C) through two Gemco powder valves (Figure 10). Powder is fed from the hopper onto the hydrofluorination reactors (H-6A, B, C) by UO_2 screw conveyors (H-31A, B, C). The powder is moved by mechanical vibration along the reactor to the powder outlet where it is discharged into UF_4 hoppers (F-14A, B, C).

From the UF_4 hoppers, the UF_4 screw conveyors (F-15A, B, C) feed the powder onto fluorination reactors (F-2A, B, C). The powder is moved along these reactors by vibration, and the powder is consumed by F_2 gas which leaves a residue or ash that is discharged through Gemco dust-tite valves into the ash receivers (F-13A, B, C).

2. Equipment Function And Control

a. UO_2 Powder Transfer

UO_2 powder is received in standard thirty gallon, non-returnable, steel drums. Transfer from the drums to the UO_2 feed hoppers is done in such a way that air contamination is held to a minimum.

The drum,as received from storage, is placed on a dolly and rolled into a dry box located on the plant floor near the feed platform. In the dry box the lid of the drum is replaced with an inverted funnel which is closed with a type "B" Gemco valve. The drum is inverted on the dolly and rolled out of the dry box. It is then picked up by the overhead crane, raised above the level of the feed platform and lowered onto a special adapter located on top of the UO_2 feed hopper. This adapter consists of a type "T" Gemco dust valve surmounted by a Plexiglass enclosure. The small end of the funnel on the drum seals against a rubber ring gasket located on the bottom of the enclosure and the flanged portion of the valve seats against the top of the enclosure. The drum is clamped in position, and the powder is dumped by opening both Gemco valves. A vacuum cleaner is connected to the enclosure to sweep out any UO_2 dust that filters back past the rubber gasket. After the drum is emptied, the Gemco valves are closed and the drum is returned to the dry box. The funnel is removed, the cover replaced and the drum transferred to a contaminated storage area.

b. UO_2 Feed Hoppers (H-17A, B, C) (Figure 9)

Each feed hopper (H-17A, B or C) is sized to hold approximately one day's supply of UO_2 powder. The hoppers are constructed of Monel and are made integral with the UO_2 screw conveyors

(H-31A, B, C). Each hopper is provided with a slide gate to cut off flow of powder in case it is necessary to remove a screw flight for maintenance.

The feed hoppers are mounted on dial scales (WI-777, 797, 817) and the indicated weights are transmitted (through WIM-778, 798, 818) to weight recorders (WR-779, 799, 819) in the control room for a continuous record of the UO_2 feed rates. The dial scales are equipped with relays (PBS-969, 971, 973) which actuate high level alarm lights (AI-970, 972, 974) to indicate when the hoppers are full. The alarm lights are located on the loading platform near each hopper.

c. <u>UO_2 Screw Feeders (H-31A, B, C)</u> (Figure 9)

Powder is fed from the UO_2 feed hoppers by screw conveyors (H-31A, B, C) to the hydrofluorination reactors (H-6A, B, C). The conveyors can be started or stopped by control buttons located at the equipment and stopped by control buttons located in the control room. An indicator light in the control room shows when the screw motor is operating. The amount of powder fed by the screw conveyors is regulated locally by changing the setting of the variable speed drive (12 rpm to 50 rpm). To prevent loss of the powder seal between the feed hoppers and reactors, the scales are equipped with relays (PBS-780,800, 820) to shut off each screw motor when the level in the respective hopper reached 300 pounds.

The UO_2 powder is preheated in the screw feeders to $700^{o}F$. The temperature of the powder is controlled by TIC-436, 437, or 438 located in the control room (Panel 6) through TE-406, 407, or 408 located on the outer shells of the screws. The stated temperature for the UO_2 preheater must not be exceeded; if the initial reactor temperature is exceeded in the screw, the conversion to UF_4 will be retarded and caking may occur.

d. <u>Hydrofluorination Reactors (H-6A, B, C)</u> (Figure 11)

The hydrofluorination reactor assemblies consist of Inconel troughs driven by conventional Link-Belt oscillating conveyor units. These positive action, roller bearing, eccentric type, oscillating conveyors are driven by Link-Belt electrofluid drives through variable speed reducers to the eccentric shaft and connecting rod assembly.

The reactor troughs have an oscillating stroke of one-eighth inch and can be operated between 600 rpm and 1200 rpm on the eccentric. The reactors and accompanying framework are supported on several pairs of legs set on opposite sides of the troughs. Torsion bars are fixed at each leg and half-way between a pair of legs and thus serve as reactor springs in absorbing the energy of the trough movement at each end of a stroke. Electrical and speed controls are located near each drive motor while auxiliary stop buttons and indicating lights are located in the control room.

e. Solids Feed Control

To obtain the required conversion of UO_2 to UF_4, it is necessary to keep the powder in contact with HF gas a minimum of four hours. This is accomplished by vibrating the reactors on an intermittent cycle. It is necessary to feed UO_2 to the reactors on a corresponding cycle to prevent build-up and subsequent caking of powder near the inlet end.

The combination of intermittent cycles is accomplished by the use of three timers in the electrical system of each reactor line - (a) one time switch (range of switch is 0 to 30 minutes on both cycles) is set for an "on" cycle of approximately one minute and an "off" cycle of approximately 14 minutes; (b) two time delay relays (ranges of relays are 0 to 30 seconds) are set for a delay of approximately 5 seconds. The sequence of operations for the timers is as follows:

1. The time switch turns on, starting the screw feeder motor and the first delay relay.
2. After the number of seconds set on the delay relay has expired, the relay starts the reactor motor.
3. The screw and reactor continue to run until the "on" time set on the time switch has expired.
4. The screw then stops and the second time delay relay is energized.
5. The reactor continues to run until the second delay relay reaches the end of its cycle at which time the reactor motor is stopped.
6. The cycle is repeated at the end of the "off" time set on the time switch.

If necessary, the reactor and screw feeder can be operated continuously by closing the timer bypass switches, and either unit can be operated independently of the other by opening or closing the appropriate lock-out switches.

The exact settings required on the various timers for normal operation of the system must be predetermined during shakedown operations and will depend on the characteristics of each particular reactor unit.

The switch which stops the screw feeder when the level in the feed hopper reaches the set "low" point does not affect the operation of the reactor vibrator.

f. Reactor Temperature Control

The optimum conditions for the conversion of UO_2 to UF_4 require the gradation of temperatures from 750° to 1025°F in the hydrofluorination reactors. The powder inlet end is at the lowest temperature and the powder outlet end at the highest. The furnaces are divided into four temperature control zones with separate control for top and bottom elements in each zone. Zone 1 consists of one five foot furnace section. Zones 2 and 3 consist of two five foot sections each, and Zone 4 consists of three five foot sections. Each furnace zone is controlled by two TIC's (eight controllers to each reactor) connected to thermocouples (TE-382 through 405) which are located in the top and bottom sections. In addition, each reactor is supplied with eight thermocouples (TE-1010 through 1033) which measure the bottom temperature at other points along the reactor. The temperature recorders (TR-1052, 1053, 1054) connected to the latter thermocouples and the temperature controllers (TIC-412 through 435) are located in the control room. A complete listing of thermocouples, controllers, and recorders is given on Figure 12 in the appendix. The drawing shows the approximate location of each thermocouple in each furnace section.

g. UF_4 Feed Hoppers (F-14A, B and C) (Figure 9)

The UF_4 feed hoppers (F-14A, B and C) are of Monel construction and are designed to hold approximately 300 lbs. of UF_4. They serve to supply UF_4 to the fluorination reactors and to provide a gas seal between the HF and F_2 gas zones.

The hoppers are mounted on dial scales (WI-782, 802, 822) and high level alarm horns (AI-783, 803, 823) are provided to indicate when the hopper is too full (this could be caused by excessive flow of UF_4 into the hopper or low flow of UF_4 to fluorination reactor). Low level alarm horns (AI-784, 804, 824) indicate when the level of the hopper reaches a dangerous minimum point. At this time, a horn blows, and a time delay switch is energized; after a predetermined time the delay switch cuts off the motor to the UF_4 screw feeder (F-15A, B, C). Should the screw be allowed to stop for a considerable length of time when it is full of powder exposed to fluorine, there is danger of caking occurring in the screw. The time delay switch will, in most cases, give operating personnel time to correct the faulty condition.

h. UF_4 Screw Feeders (F-15A, B, C) (Figure 9)

Powder is fed from the UF_4 feed hoppers by screw conveyors (F-15A, B, C) to the fluorination reactors (F-6A, B, C). These conveyors can be started or stopped by control buttons located at the equipment and stopped by control buttons located in the control room. An indicator light in the control room shows when the screw motor is operating. The amount of powder fed by the conveyors is regulated locally by changing the setting on the variable speed drive (2 rpm to 6 rpm). As explained in the previous section, the screws are automatically shut off when the powder level in the hoppers reaches a set low point.

The screw drive units are equipped with Falk controlled torque couplings to prevent damage to equipment if a screw jams during operation.

i. Fluorination Reactors (F-6A, B, C) (Figure 11)

The design of the three fluorination reactor assemblies is similar to that of the hydrofluorination reactors. The reactor troughs are constructed of Monel instead of Inconel and are ten feet shorter. The supporting frameworks and driving mechanism are identical in design.

j. UF_4 Flow Control

During normal operation, the fluorination reactors are vibrated continuously and the feed to them is also continuous. Since a pile-up of UF_4 in the reactor trays causes caking, interlocking controls prevent feed screw operation when the vibrator is stopped. However, to allow independent operation of the screw and the reactor for equipment shakedown or testing purposes, normally locked-out bypasses around interlocking controls are provided. The electrical controls for the reactors are mounted locally with auxiliary "stop" buttons and motor indicator lights located in the control room.

k. Temperature Control

The optimum conditions for fluorine cleanup and fluorination of UF_4 require the gradation of temperatures from 800 to 950°F along the reactor. The furnaces are identical in construction and are controlled in the same manner as those used on the other reactors. There are three zones of control on each reactor with Zone 1 consisting of two five-foot furnace sections, Zone 2 consisting of one five-foot section, and Zone 3 consisting of three five-foot sections. TIC's 460 through 477, located in the control room, regulate the temperatures of the individual top and bottom sections in each zone from TE's 442 through 459, and TR's 1052, 1053, 1054, also located in the control room, record temperatures at other points along the bottom of the reactor from TE's 1034 through 1051. Figure 12 in the appendix gives a complete listing of these elements and instruments with the approximate location of the thermocouples in the furnace sections.

l. Bellows Connectors (Figure 13)

Double bellows assemblies of different dimensions, depending on point of service, are provided to connect the vibrating reactors to stationary parts. The flexible connectors used in the plant are supplied by Zallea Bros. and are located at the following points:

1. On the shell of each UO_2 and UF_4 screw feeder.
2. At the powder inlet and outlet ends of each reactor.
3. At the powder inlet end of each UF_4 hopper.
4. At the inlet of each ash receiver.
5. At the gas line connections to each reactor.

Each bellows assembly consists of (1.) an outer stainless steel bellows, (2.) an inner Monel or Inconel bellows (depending upon service), (3.) steel end flanges, (4.) a Monel liner where the assembly is in contact with moving powder, and (5.) an opening through one end of the flange to provide a nitrogen buffer to the annular space between bellows at a pressure slightly above operating pressure. Figure 13 shows the types of bellows used and the points at which each type is located.

The double bellows with buffering is provided to minimize the hazard which may be caused by a ruptured bellows during operation.

Nitrogen from the main header goes through reducing valves (PCV-1093, 1094, 1095, 1096 and 1097) and flow elements (FE-1098 through 1102) to individual cocks for each bellows assembly (Figure 12). A rupture in any bellows in the system is indicated by a drop in pressure on PI-1103, 1104, 1105, 1106 or 1107. The exact location of a leak can be determined by cutting off the nitrogen to each bellows assembly connected to the particular PI showing the drop in pressure, until the rupture causing the gas flow is found.

Panel boards containing the reducing valves, flow elements, pressure gages, and two-way cocks for the bellows buffering system are located at the following points:

1. One near the UO_2 hopper scale dial of the middle reactor line;
2. One near the discharge end of each hydrofluorination reactor;
3. One near the ash receiver scale of the middle reactor line.

m. <u>Screw Feeder and Reactor Furnaces</u>

The furnaces for the UO_2 screw feeders and for all the reactors were fabricated by Hevi-Duty Electric Company. The reactor furnaces are made in split five-foot sections which are interchangeable throughout except for the top section at the gas inlet port on the fluorination reactors. Each half of any section contains nichrome elements with a capacity of 7.5 KW operating at 120 volts maximum. In order to provide reduced input to the elements, all elements in the lower half of each section are connected to one phase and all elements in the upper half are connected to the other phase of the 2 phase secondary of a Scott-connected power transformer. Each upper and lower furnace section has its own contactor which is wired directly to the secondary of the transformer. Each secondary phase of the transformer is provided with a six-tap switch so that the voltage applied to the heating elements may be reduced from 120 volts to 60 volts, by steps, which results in an input of 25% of full load on the lowest tap.

A single push button is provided for each furnace so that the entire furnace can be connected or disconnected from the power supply without operating individual switches for each zone.

The transformers and contactors are located in the feed plant load center room in the southwest corner of K-1131.

The three screw feeder furnaces are of standard tube furnace construction having a capacity of 10 KW each at 120 volts. Each furnace has five thermocouple openings and each is supplied with a contactor and a temperature controller.

The temperature controllers on all furnaces are provided with a thermocouple break protection device which automatically shuts off the power to that circuit should the thermocouple circuit open.

n. <u>Special Hood and Dust Filtering Equipment</u>

Even though powder handling has been reduced to a minimum, it would still be possible to contaminate the feed plant with dust during the UO_2 hopper loading step and the ash removal step. In addition to these two steps of operation, contamination might occur when bellows assemblies are changed or when the reactors, hoppers, or screws are opened for inspection and repairs.

A special vacuum cleaning system has been installed in the feed plant to remove dust which would otherwise cause contamination.

The system includes a Lamson Corp. air blower which is rated at 425 cfm at 2.5 psi suction pressure and a Lamson Corp. dust separator containing a very fine mesh cloth filter bag having approximately 200 square feet of filter area. The inlet to the blower and filter unit is tied into a total of 14 outlets located around the feed plant as follows:

a. One outlet near each ash receiver (three).
b. One outlet near each UF_4 hopper (three).
c. One outlet near each UO_2 screw (three).
d. One outlet at the Gemco valve on each UO_2 hopper (three).
e. One outlet connected directly to the combination dry box and clean-out booth.
f. One outlet inside the dry box.

The outlets listed under a, b, c and f have hinged covers which remain closed except when a hose is inserted in the line for cleaning up spilled powder or removing dust from equipment opened for repairs.

The outlets at the Gemco valves on the UO_2 hoppers are permanent connections, but contain slide gates which are normally closed. The gates can be opened to pick up dust filtering out through the rubber gasket between a loading drum and the Gemco valve during the UO_2 filling operation. Provisions have been made to allow a small stream of air to flow continuously in and around the gasket and then into the vacuum system to pick up this dust.

The outlets near the ash receivers are to be used to collect dust from the equipment (bellows and reactor flanges) in that area and also to connect to the dry boxes in the ash pit itself whenever an ash receiver is being changed.

The combination dry box and clean-out booth is located at ground level on the west end of the feed plant. This box is of dust-tight construction and contains two sets of gloved ports on each of two sides for use in handling contaminated equipment inside the box.

In addition to serving as a booth for cleaning dust from small pieces of contaminated equipment in the feed plant prior to their removal from the area, the dry box also serves as a dust-tight hood where the lids on shipping drums are exchanged for the special covers prior to loading the UO_2 hoppers and regular lids are again installed on the empty drums.

Sufficient lengths of flexible rubber hose are provided to reach all points of dust contamination from the nearest vacuum cleaner outlet.

o. Ash Handling System

Steel drums similar in design to the feed drums are used to collect the ash from the fluorination reactors. Modifications have been made to the drums to make them fit handling and shielding equipment.

Each ash drum is fitted with a special cover and then placed in a one inch thick steel can which serves as a shield against radiation*, and in addition provides the compressive force necessary to seal the drum to the adapter cover gasket. The entire assembly is lowered into the ash collection pit and placed on a dolly which rolls along on a track built into the pit. The dolly is equipped with two lifting tracks which are used to lift the assembly against a flange which connects to the reactor. When the dolly has been properly positioned, the lifting tracks engage two T-section lifting lugs. These lugs are keyed to two special jack screws which are raised and lowered by a chain and sprocket assembly operated at the floor level through a handwheel and drive shaft connected to one sprocket.

After the can has been raised and sealed against the gasketed reactor flange and before the Gemco valves are opened to admit ash, the entire connection is checked to insure tightness.

At the same time the can is sealed against the reactor, it is also pressed against a plate, bolted to the lower reactor bellows and rigidly suspended from a floor mounted scale.

The ash receiver assembly is then free to move on the scale levers independent of tray vibration, and the weight of ash entering the receiver can be checked as often as necessary.

When the can is full, the valves are closed, and the assembly is disconnected and moved from the pit to a storage area where the shield is removed and returned to the plant for use on another receiver.

*Letter, KS-120, "Shielding Requirements For Ash Container For Feed Plant", Dr. H. F. Henry to Mr. R. B. Korsmeyer, April 11, 1950.

During the time the receivers are being changed, the ash is allowed to collect in the valves and bellows directly below the fluorination trays.

The weight in an ash receiver is indicated on WI-956, 958 or 960. Alarm V-AI-957, 959 or 961 will be actuated when the weight of ash reaches a predetermined value.

The ash pit is about six feet deep, three feet wide and extends the full width of the reactor lines. The pit was located below the floor level in order to keep the reactor line elevation as low as possible.

The section of the pit directly below each reactor line is fitted with a dry box vented to the central filter system to prevent escape of the reaction gases and radioactive ash in case a leak occurs around the ash receiver.

Strip heaters are located in each dry box to maintain the temperature there at approximately 200°F to prevent condensation of UF_6 in the ash receivers.

B. HF Circulation System

1. Flow (Figure 2)

Anhydrous HF flows from the gas mixing chamber H-4 (Figure 14) to the superheater H-3 (Figure 15) to the preheaters H-5A, B, C (Figure 16) and then into the hydrofluorination reactors H-6A, B, C.

The exit gases from the reactors (HF + H_2O) flow through header HFG-12 to the inlet HFG-13A or B of the partial condensers H-7A or B (Figure 17) where part of the HF and essentially all the water vapor condense as a 65% by weight HF solution.

The liquid-gas mixture flows through HFL-15 to the hold tank H-9 (Figure 18) where the two phases separate. The gas leaves the hold tank through line HFG-32 to the recirculation blowers H-12A or B (Figure 19). The gas is pumped by the blowers through line HFG-24 into the mixing chamber H-4.

Provision is made for bleeding N_2 out of the system by taking a small flow from line HFG-24 through line HFG-28 into the NaF traps H-13A and B (Figure 20), where the HF is adsorbed and the N_2 vented to the stack. The traps are regenerated by heating and the HF is driven back into the system through line HFG-30.

Make-up HF comes from the F_2 plant HF vaporizers through line HFG-5. The amount of HF added is controlled by the pressure in the mixing tank.

The 65% HF solution drains from the hold tank through HFL-16 to the HF still H-10 (Figure 21). The still separates the 65% solution into a 38% HF-H_2O solution and essentially anhydrous HF gas. The product gas flows from the top of the HF still to a reflux condenser H-11 (Figure 22). A portion of the gas condenses and returns to the column through line HFL-18. The remaining gas flows through HFG-19 which joins the recycle stream, HFG-32, on the suction side of the HF pumps H-12A and B. The 38% HF-H_2O mixture overflows from the bottom of the HF still through HFL-25 to the azeotrope cooler H-14 (Figure 23). Here the liquid is cooled to approximately room temperature and then discarded as waste to the neutralizing pit through line HFL-27.

a. HF System Pressure and Flow Control

The pressure in the HF recirculating system is controlled automatically by regulation of the HF supply to the mixing chamber. PRX-752 which regulates control valve CV-754 is set to hold the desired system pressure. In the event CV-754 fails in such a manner that the HF supply is either cut off entirely or increases above the demand, two other control valves (CV-753 and CV-755) act to remedy the condition. Control valve CV-753 will open and admit nitrogen to the system if the pressure in the mixing chamber falls below 0 psig. In a similar manner, control valve CV-755 will open and release gas to the stack if the pressure in the mixing chamber rises above 1 psig. PBS-986 actuates alarm V-AI-987 when CV-755 opens to relieve high pressure and PBS-984 actuates alarm V-AI-985 when CV-753 opens to relieve low pressure.

In addition, the reactor troughs are individually protected from high or low pressure by air operated relief valves CV-772 and 792, and 812 which open at 3 psi above and below atmospheric pressure. Pressure switches PBS-768, 788, and 808 actuate electrically operated transfer cocks XX771, 791 and 811 which in turn operate the control valves when the tray pressure is above 3 psig and PBX-996, 997 and 998 open the valves for the low pressure condition. Thus, excess pressure is relieved to the main header HFG-8 feeding the trays, while relief is provided to the trays if the tray pressure is low. Each time the relief valves open, audible and visible alarms are actuated. Alarms A-AI-769, 789, and 809 are high pressure alarms; A-AI-770, 790, and 810 are low pressure alarms. Tray pressures may be read on either PI-767, 787 and 807 in the control room or on PI-766, 786, and 806 at the equipment.

The amount of gas flowing to each reactor tray is controlled by valves CV-776, 796, and 816. The positions of these valves are set and adjusted manually by air loading through instruments PIX-775, 795 and 815.

2. Equipment Function and Control

a. Superheater (H-3) (Figure 15)

The superheater is designed to supply heat to the gas from the mixing chamber to (1) dissociate any HF polymers present and (2) to vaporize any mist carried over from the evaporators.

The superheater is heated electrically and the shell temperature is controlled by an on-off Partlow switch TBS-757. The gas outlet temperature is read on TI-487-P-point #TE-756. Although the gas temperature at this point need only be 180°F to assure complete dissociation, it is probably desirable to run the superheater at its maximum working shell temperature (650°F) in order to lessen the load on the preheaters H-5A, B, and C.

b. Preheaters (H-5A, B, and C) (Figure 16)

The preheaters are designed to raise the temperature of the HF stream entering the reactors to the reaction temperature (1000°F). The preheaters are heated electrically and the shell temperatures are controlled by TIC-439 P-6, 440 P-6, and 441 P-6. The temperatures of the gas entering the reactors are read on TI-487 P-13.

The maximum allowable shell temperature is 1200°F.

c. Partial Condensers (H-7A, B) (Figure 17)

The partial condensers are designed to condense the water from the HF reactor exit gases. The exit gas temperature from the partial condensers is maintained constant at 185°F by regulation of the cooling water flow to the condensers. The desired temperature is set on TIX-748 P-8 which regulates the water flow through CV-749 in accord with process demand.

The exit gas temperature should not be allowed to rise over 185°F since, at higher temperatures, the concentration of water in the gas phase in equilibrium with the condensed liquid becomes high (thus increasing the water concentration in the recycle stream to the reactors). This excess water may cause a decrease in conversion of UO_2 to UF_4 since the reaction is reversible. Lower exit gas temperatures will cause an increase in the amount of HF condensing with the water. However, this condition is not serious in that its only effect is to place a small additional load on the distillation column H-10.

d. Hold Tank (Still Feed Tank) (H-9) (Figure 18)

The 65% HF-water solution condensed in the partial condensers is stored in the still feed tank H-9. The liquid level in the tank is measured by LBM-962 and indicated by LIX-963 P-8. The amount of feed to the still is regulated manually by changing the air pressure to control valve CV-968 as indicated by LIX-963 P-8. The still feed tank can be drained through line HFL-16 or HFL-26. Either line may be used through proper valving to empty the tank to the still or the neutralization pit. CV-968 is located in line HFL-16 below the junction of HFL-16 and HFL-26. Line HFL-16 extends upward six inches above the hold tank bottom and line HFL-26 is flush with the tank bottom.

e. HF Still (H-10) and Partial Reflux Condenser (H-11) (Figures 21 and 22)

The HF still is designed to rectify the 65% HF-H_2O solution into essentially anhydrous HF gas which is returned to the recycle system for reuse and an azeotropic solution of HF and water (38% HF by weight). The HF still is heated electrically. There are two sets of column heaters controlled by TBS-731 and TBS-732. The reboiler heaters are arranged in three sets. The main set of heaters is normally in use and, if the flow of liquid to the still demands it, the other two sets of heaters can be manually switched into the circuit either individually or together by a selector switch (XX739 P-7). The heat input to the reboiler is controlled by TBM-736, TBC-737 and TRX-738 P-8. In addition TBS-735 acts to protect the reboiler against overheating.

The flow of cooling water to the partial reflux condenser H-11 is controlled by CV-745 in the water inlet line. The position of the valve is regulated by the HF gas temperature in line HFG-19 (at the outlet of the partial condenser) by means of TBM-742, TBC-743 and TIX-744 P-8. The desired temperature is set on TIX-744 P-8.

The pressures in the still system are indicated on PI-734 through DBM-733 located near the reboiler and PI-741 through DBM-740 located in line HFG-19 at the partial condenser outlet.

f. Blowers (H-12A and B) (Figure 19)

The HF blowers are designed to circulate gas from the partial condensers back to the reactor. The rated capacity of each blower is 200 CFM against a head of nineteen inches of water.

The shaft seals on the blowers are similar in design to the seals developed for the Elliott Blowers. The seal feed instrumentation is located on its own panel board close to the pumps. The nitrogen flow to the seal is read on a pressure gauge (PI-1146L) and the seal feed pressure on PI-1147L. An alarm V-AI-1150L signals a high nitrogen flow to the seal. The same instruments are used by both blower seals; switching from one to the other is done by opening and closing the appropriate block valves.

g. NaF Traps (H-13A and B) (Figure 20)

A bleed is maintained from the HF recycle system to remove inert gases as they accumulate. The bleed flow is regulated by a continuous HF analyzer recorder-controller XX1222 which actuates control valve CV-764. The flow is measured and indicated by FE-760, DBM-761 and PR-762. Two NaF traps, arranged in parallel, are located in the bleed line and serve to remove the HF from the bleed stream by chemi-sorption. The adsorbed HF is later evolved and returned to the recycle stream by raising the temperature of the NaF traps. The traps are designed to run alternately, one trap adsorbing, the other regenerating. The temperature of the trap shell during either the adsorption or regeneration cycle is controlled by a Partlow temperature switch located on each unit (TBS-758, 759). The set point on the Partlow switch for the adsorption is 200°F and for the regeneration 900°F. TE-726 and 727 measure the outlet gas temperature during the regeneration cycle. The temperatures are indicated on TI-487. Should the trap pressure exceed 1.5 psig, DBM-1075 or 1077 opens CV-1076 or 1078 to relieve the pressure to the stack.

The NaF tray system can be by-passed through HFG-28A which joins the system vent line.

C. Primary Recycle System (Figure 3)

1. Flow

The gas mixture of the following approximate composition, 25% F_2, 37% N_2, 33% O_2, 3% UF_6, and 2% HF, leaves the mixing drum F-1 through line FG-2 where the stream is split into the three headers FG-4A, B and C leading to the fluorination reactors, F-2A, B and C.

At each reactor inlet, the gas stream splits, part flowing up the reactor countercurrent to the UF_4 flow to form the secondary stream and part flowing down the reactor concurrent with the powder flow. The lower section of the reactor is the main reaction section, and the gas, of the following approximate composition, 14% F_2, 37% N_2, 13% UF_6, 34% O_2, and 2% HF, leaving the unit at the powder discharge end constitutes the primary recycle stream.

The primary stream leaves the reactors through lines UG-5A, B and C all of which lead to header UG-6. The mixture flows into either of two gas coolers F-3A or B (Figure 25) through line UG-7A or B. From the coolers, the flow is through line UG-8A or B into UG-8 and then into either of two primary gas compressors F-4A or B (Figure 26) through lines UG-9A or B. From the compressors, the gas flows through headers UG-10A or B to UG-10 and then through inlet lines UG-11A through 11F into whichever of the primary cold traps F-5A through 5F (Figure 27) is in service.

The gas stream, now containing approximately 15% F_2, 42% N_2, 3% UF_6, 38% O_2, and 2% HF, leaves the cold traps through exit lines RG-12A through 12F and flows through header RG-13 back to the mixing chamber F-1 (Figure 13) where it combines with the secondary recycle stream and make-up F_2.

2. Equipment Function and Control

a. Mixing Chamber (F-1) (Figure 13)

The mixing chamber receives the primary and secondary recycle streams and make-up fluorine from the fluorine plant. The chamber has a volume of 5.3 $ft.^3$ and is a surge drum for the system.

The flow of make-up F_2 to the mixing chamber is controlled by the gas analyzer XX-953, the sample point for which is located in line FG-2. The analyzer is set for a specific ratio of fluorine to inerts, with a correction for the small percentage of UF_6 present in the stream. If the concentration of F_2 rises above the set value, the analyzer, through CBC-954 and CRX-967, closes the flow control valve CV-955 in line FG-1 from the fluorine plant. If the percentage of F_2 decreases below the set value, CBC-954 will cause the valve CV-955 to open and permit more fluorine to enter the mixing chamber from the fluorine plant.

b. Fluorination Reactors (F-2A, B, C)

The function of these units and specific details concerning their design were described in the section, "Solids Flow System."

The flow of gas through lines FG-4A, B and C is divided among the reactors by holding constant pressure drops across the flow elements, FE's-831, 848, 865. The differential pressures are transmitted by DBM's-832, 849, 866 and recorded in the control room on PRX's-833, 850, 867. The flows are regulated by manually adjusting control valves, CV-834, 851, 868, from the controllers, PRX-833, 850, and 867.

The reactor troughs are individually protected from high or low pressure by air operated relief valves, CV-841, 858 and 875, which open at 3 psi above and below atmospheric pressure. Mercoid pressure switches PBS-837, 854 and 871 actuate three-way solenoid transfer cocks which in turn operate the valves when the tray pressure is above 3 psig and PBS-781, 801 and 821 actuate the transfer cocks to open the valves for low pressure conditions. Thus, excess pressure in the trays is relieved to the main header, FG-2, feeding the trays, while relief is to the trays if the tray pressure is low.

Each time the relief valves open, audible and visible alarms are actuated. Alarms AI-838, 855 and 872 are high pressure alarms; AI-839, 856 and 873 are low pressure alarms.

The temperature of the gas mixture leaving the reactors is measured in the exit lines UG-5A, B and C by temperature elements TE-490, 491 and 492, and is indicated in the control room on the indicator TI-487.

c. Main Gas Coolers (F-3A and B) (Figure 25)

The primary gas coolers F-3A and B cool the reactor exit gas from 900°F to approximately 140°F. The coolers are supplied with 120°F water from the water recirculation system located in the fluorine plant. (The water in this system is held at 200°F but is mixed with cold water and controlled at 120°F for use in the feed plant.) The water rate to the coolers is manually controlled by block valves in the water outlet lines from the coolers. The temperature of the gas is measured at the exit of the primary gas blowers described below.

d. Primary Gas Compressors (F-4A and B) (Figure 26)

The primary gas compressors, which are 100 cfm Roots-Connersville positive displacement gas compressors, pump the primary stream from the reactors through the cold traps and back to the mixing chamber.

Instrumentation for control valves around the compressors serves to maintain constant pressure in the reactor trays. A bypass line UG-36 connects UG-10 at the discharge of the compressors to header UG-6 at the inlet of the gas coolers. DBM-894 in header UG-6 transmits the pressure at the gas cooler inlet to an automatic pressure controller and recorder PRX-895 P-11, which, through PBC-896, actuates control valve CV-897 in the bypass line UG-36.

If the suction pressure of the compressors rises above the set point, the control valve CV-897 closes and the gas flow to the cold traps is increased, thus maintaining a constant suction pressure. If the pressure in the system drops below the set value, the control valve CV-897 opens, increasing the compressor recycle stream, thus holding the suction pressure at the set point. PR-899 in the control room measures the discharge pressure of the compressors through DBM-898 located in UG-36.

In order to prevent the differential pressure across the compressors from exceeding a safe limit, relief lines connect the suction and discharge of each compressor. DBM's-1002 and 1004 connected between these two points actuate control valves CV-1003 and 1005 in the relief lines and if the differential pressure across the compressors exceeds 2 psig, the control valves open, permitting recycle around the compressors until the excessive pressure differential is relieved.

The temperature of the gas leaving the gas compressors is measured by TBM-900 in UG-10 and is recorded in the control room on TR-901. Alarms AI-903 and 904 indicating high and low gas temperatures are also located in the control room. Electrical controls and indicating lights for the compressors are located near the equipment.

A flow of air is maintained to the compressor shaft seals to prevent leakage of process gas to atmosphere. The total flow of air to a compressor is measured by the pressure drop across a flow element (FE-1161) and indicated on a pressure gage (PI-1158). The seal feed (air) pressure is indicated on PI-1159. An alarm (V-AI-1162L) is provided to warn of a high flow to a seal. The defective seal is located by momentarily closing and opening the block valve to each seal and noting the change in air flow as shown on PI-1158. The seal feed control panel is located adjacent to the compressors.

e. Primary Cold Traps (F-5A through 5F) (Figure 27)

The gas flows from the compressors to the onstream cold traps. Of the six primary cold traps in the plant, two are onstream, two are in standby condition and the remaining two are draining to the vaporizers. The exit gas from the cold traps returns to the mixing chamber through line RG-13.

Flow elements FE-651, 652, 653, 654, 655 and 656 in the exit lines from the traps through DBM's-657, 658, 659, 660, 661 and 662 and PI's-663, 664, 665, 666, 667 and 668, respectively, indicate the flow of gas from the traps and show when a particular trap is filled or plugged and needs to be taken offstream. In addition, alarms A-AI-675, 676, 677, 678, 679, 680L and V-AI-681, 682, 683, 684, 685, 686-P-12 indicate plugged traps.

D. Secondary Recycle System (Figure 3)

1. Flow

The secondary recycle stream flows countercurrent to the powder (UF_4) in the reactor F-2A, B or C and leaves the reactor through line RG-14A, B or C. In each of these lines, the stream passes through a dust separator F-38A, B or C (Figure 28), a gas cooler F-7A, B or C (Figure 23) and a dust filter F-6A, B or C (Figure 29). The secondary recycle stream flows in header RG-16 to the compressor F-8A or B (Figure 26). Another line RG-40 ties into RG-17 at the suction side of the compressor. This line is provided so that the secondary recycle stream can bypass the cleanup section of the tray. Line RG-40 originates at the discharge of the primary compressor.

The secondary stream flows through RG-20 to the secondary cold traps F-9A, B or C (Figure 27), enters one of the cold traps through RG-21A, B or C, is stripped of UF_6 and leaves through RG-22A, B or C to header RG-23. It then flows through an NaF trap F-10A or B (Figure 20), entering the trap through RG-24A or B and leaving through RG-26A or B. The secondary recycle stream then returns through RG-27 to the mixing chamber F-1 to combine with the fluorine supply and primary recycle streams.

Inert gas is purged from the system through RG-29 which branches from RG-27. The purge gas passes through an alumina trap F-22A or B (similar to Figure 20) and exhausts to the atmosphere through RG-38A or B and RG-39 to the vent line leading to the stack. Nitrogen make-up to the system is introduced into line RG-27 through line N-24.

2. Equipment Function and Control

a. Reactor Cleanup Section

The first 10 ft. section of each fluorination reactor is used to clean up fluorine from the secondary recycle stream so that the loss of fluorine from the system through purging may be kept at a minimmm. The secondary recycle stream can be taken entirely through one cleanup section or divided in any proportion among the three cleanup sections. The flow through the cleanup section is controlled by adjusting the control valve CV-828, 845 or 862 through PIX-827, 844 or 861 which indicates the differential pressure across the orifice FE-825, 842 or 859 through DBM-826, 843 or 860. If desired, the secondary recycle stream may be bypassed from the reactor cleanup section by closing the control valves and opening the line between the discharge side of the primary blower and the suction side of the secondary blower (RG-40). Details of the function and control of the fluorination reactor are given under "Solids Flow".

b. Separators (F-38A, B and C) (Figure 28)

The separators are internally baffled 1 ft. diameter x 2-1/2 ft. long sections of Monel pipe which are located in a direct run of pipe immediately over the secondary recycle stream outlet from the reactor. The function of the separator is to provide a low velocity section wherein particles of powder carried from the reactor with the secondary recycle stream are allowed to settle. Baffles inside the separator aid the settling by reversing the direction of gas flow. Powder collected in the separator may be fed back by gravity to the reactor by temporarily stopping the flow of gas through the separator.

c. Secondary Gas Coolers (F-7A, B and C) (Figure 23)

A gas cooler is located in each line carrying secondary recycle flow from the reactors. Its purpose is to cool the gas leaving the reactor at 900°F to approximately 150°F to prevent damage to equipment and instruments farther downstream. The gas cooler is an eighteen foot long jacketed section of one inch Monel pipe. Water from the feed plant water circulating system is used to cool the gas. The inlet water temperature is maintained at 120°F to avoid condensation of UF_6 in the cooler. The water flow rate to the cooler is adjusted manually to give the desired gas temperature as read on TI-487 from TE-484, 485 or 486 in the exit line from the cooler. Warning of malfunctioning of the cooler is given by high and low temperature alarms AI-929 P-10 and 931 P-10 operating from TBS-928 and 930 located in the secondary blower discharge line.

d. Dust Filters (F-6A, B and C) (Figure 29)

The dust filters contain a bundle of 120 five foot long barrier tubes in a tube sheet encased in a 6 ft. long, 16 inches diameter, schedule 30, nickel-plated steel pipe. The secondary recycle stream from each reactor in passing through the 96 sq.ft. of barrier surface is filtered free of any fine particles of dust which might escape the settlers. The dust filters are provided as insurance against plugging of instruments and lines in the secondary recycle stream. Plugging of the dust filter is determined by observing the pressure drop across the filter; i.e., noting PI-830L, 847L or 864L (from DBM-829, 846 or 863) in relation to the controlled pressure of the reactor, as shown on PI-964, 965, 966 P-10 and 836, 853 and 870L.

e. Secondary Compressors (F-8A or B) (Figure 26)

The secondary compressors are Roots-Connersville 20 cfm positive displacement compressors. A control valve CV-927 in the bypass line around the compressor is automatically positioned through DBM-924 and PBC-925 to recycle part of the flow and maintain a constant suction pressure set and read on PRX-926 P-10 (similar to the primary compressors).

Each compressor is equipped with a relief valve, CV-1072 and 1074 operated by DBM-1071 and 1073, which acts as a bypass valve when the pressure differential across the compressor exceeds 3 psi.

PR-933 P-10 operated by DBM-932 in the compressor exhaust gives a continuous recording of the compressor discharge pressure.

A seal feed system identical to that used by the primary compressors is provided for the secondary compressors. The air flow is read on PI-1152L, the pressure on PI-1153L and the alarm indicated on V-AI-1156L. The same instrument panel is used by both primary and secondary compressor seal feed systems.

f. Secondary Cold Traps (F-9A, B, C) (Figure 27)

The secondary cold traps remove the UF_6 from the secondary recycle stream by condensing it out as a solid at minus 55°F. The traps are standard "size 1" cold traps.

Since only one cold trap is required to handle the secondary recycle gas flow, one orifice (FE-687) located in the gas exhaust manifold is sufficient to indicate the total secondary flow. The secondary stream gas flow is indicated on PI-689L (actuated by DBM-688, which measures the flow through orifice FE-687). When the flow through the orifice is decreased, because of plugging in the trap, alarms A-AI-691L and V-AI-692 P-11 actuated by PBS-690 give visual indication of the low flow.

g. NaF Traps (F-10A and B) (Figure 20)

To prevent HF gas from freezing out in the cold traps, it is necessary to reduce the HF concentration in the recycle streams to 4% by volume or less. At 4% HF concentration, the HF will not condense appreciably at minus 55°F (cold trap temperature). The NaF pellets adsorb the HF from the secondary recycle gas stream. Since the secondary joins the primary recycle stream, the total amount of HF in the entire system is thus kept at a suitable operating level.

The NaF trap is a twelve inch diameter, five feet long, steel pipe. It contains two removable screens to hold the NaF pellets, and has a bolted blind flange with aluminum gasket at the top. The trap is designed for an operating temperature of 200°F and is externally heated with six 1500 watt, 230 volt, Chromalox strip heaters wired in series on a 460 volt, 3 phase, circuit. The trap insulation is three inches thick and is attached in sections for ease of removal.

During regeneration, TBS-951 and 952 maintain and regulate the trap temperature at 900°F. The outlet gas temperature is measured on the exit gas line of each trap and is indicated on TI-487.

Each trap is equipped with an air operated relief valve CV-1080 and 1082, actuated by DBM-1079 and 1081 which are set to open at 1 psi above normal operating pressure. When the relief valve opens, it vents the gas in the traps directly to the stack.

h. Alumina Traps (F-22A and B) (Similar to Figure 20)

The alumina traps are 12" diameter, 3-1/2' long, Cadmium coated, alumina filled steel traps. Their function is to remove the last traces of UF_6 that might be present in the bleed gas from the secondary recycle stream, so that no UF_6 is discharged to the atmosphere.

i. Pressure and Vacuum Relief for Fluorination System

A small amount of nitrogen and oxygen is unavoidably introduced into the fluorination system through leaking compressor glands, impurities in the fluorine, and from reaction of F_2 with small amounts of UO_2F_2 and unconverted UO_2.

To prevent build-up of non-condensibles a small amount of gas is purged continuously from the secondary recycle stream through the alumina traps to a vent line connected to the eighty foot stack*. The high pressure relief from the sodium fluoride traps F-10A and B is connected to the stack through the same vent line.

Control valve CV-945 regulates the amount of gas being purged from the system. It is actuated by DBM-940 through PBC-941 which is positioned by PIX-942. In the event it is necessary to purge a large volume of gas to the stack, (i.e., the capacity of CV-945 is exceeded) a one inch valve, CV-944, is provided as a bypass around CV-945. CV-944 is set to open at a higher pressure than CV-945.

The amount of gas purged to the stack is read on PI-948 (actuated by DBM-947) which measures the pressure differential across FE-946. PI-948 is located in the control room.

CV-939 allows the secondary recycle gas to flow into the mixing chamber F-1 in sufficient quantity to maintain the pressure in the mixing chamber at a constant value. CV-939 is actuated by DBM-934 through PBC-935 which is positioned by PRX-936 in the control room.

An increase in pressure in the mixing chamber tends to close CV-939, but if the pressure exceeds a set value on PBS-937, the relief switch overrides PBC-935 and opens CV-939. The gas thus flows from the mixing chamber back into the secondary recycle stream and the excess pressure is vented to the stack.

When the pressure indicated on PIX-942 falls below the set system pressure, CV-943 is opened by PBC-941 and nitrogen is introduced into the system to bring the pressure up to the normal operating level. Pressure in the nitrogen header is assured by an auxiliary N_2 supply system consisting of two N_2 cylinders and the necessary pressure controls. Also included is a flow indicator alarm, V-AI-1221-P-13 which indicates usage of the emergency supply.

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* Plant experience may make it expedient to install a relief valve in the bypass line around the alumina traps.

PBS-1006 actuates V-AI-1007-P-12 when CV-944 opens to relieve high pressure. PBS-1008 actuates V-AI-1009-P-11 when CV-943 opens to admit nitrogen.

A fluorine analyzer, XX-945, is connected to the bleed line and through CR-950 located in the control room shows the fluorine concentration in the bleed gas. The analyzer, XX-945, is also connected in parallel with the fluorine analyzer, XX-953, which controls the fluorine concentration in the primary recycle stream so that it may be used as a spare for this analyzer.

E. Product Handling System

1. Flow

The UF_6 product is collected in batches in the primary cold traps F-5A-F and secondary cold traps F-9A-C. A full trap containing 750 to 1,000 pounds of UF_6 is removed from the stream and the solid UF_6 is liquefied by heating the traps to 160°F. The liquid contents are drained through header UL-31 to one of three UF_6 cylinders F-19A, B or C which serve as weigh tanks and vaporizers. A fourth cylinder F-19D is provided for removal of product when the production rate exceeds the rate required for the cascade feed.

The three vaporizers are alternated so that while one is receiving liquid UF_6 from the cold traps, a second is vaporizing UF_6 at a controlled rate through line UG-34 to UG-44 to the cascade feed line PG-211-2 at K-402-7. The third vaporizer is maintained in standby condition to provide for an uninterrupted feed while cylinders are being switched.

2. Equipment Function and Control

a. Cold Traps

The six primary cold traps and three secondary cold traps, by alternating operations, condense UF_6 as a solid from the recycle stream and deliver liquid UF_6 to the vaporizers. The cold traps undergo three cycles; (1) the condensing or "on-stream" cycle during which the solid UF_6 is accumulated; (2) the heating cycle in which the UF_6 is liquefied and drained; (3) the cooling cycle in which the trap is refrigerated to -55°F in preparation for its return to the process stream.

(1) Condensing Cycle

In the condensing cycle the cold trap is at minus 55°F. Essentially no control is required during this cycle as the block valves from the refrigerant supply are open wide, as are the inlet and outlet process lines to the trap. Temperatures of the inlet head, inner jacket, outlet head and outlet gas are continuously recorded but these serve only to indicate normal functioning of the trap during this cycle. Two 16 point-Speedomax recorders are used for the primary trap temperatures and one 16 point Micromax for the secondary trap temperatures. The temperature element and recorder numbers are identified on Figure 12. A full trap is indicated by a decrease in flow through the trap. Normally, two traps in parallel are used in the primary stream with a minimum onstream time of six hours. A single trap is used for the secondary stream with a minimum onstream time of about ten hours.

(2) Heating Cycle

In the heating cycle, a full cold trap, isolated from the stream, is first evacuated and then heated electrically to 160°F. Separate heaters are provided for the inlet head, inner shell, outer shell, and outlet head. Each heater has a variac and on-off push buttons located on the heater control board. Variacs are adjusted manually to establish a maximum temperature rise of 5°F per minute at any of the temperature points recorded. Protection against overheating is provided through a heater cut-off relay operating from the Speedomax or Micromax. The relay will trip when any temperature exceeds a preset value and will interrupt the circuit to all heaters on the trap. This condition is indicated by an alarm (A-AI-876 to 884) in the cold trap area and an alarm (V-AI-885 to 893) in the control room. When proper temperatures are restored, the heaters may be turned on again by means of a push button on the heater control board.

Protection against excessive pressures is similar to the temperature protection. Pressure switch (PBS-633 through 638) will trip the relay to all heaters when the pressure exceeds a preset value and will actuate alarms on the cold traps and in the control room (A-AI-639 through 644L, V-AI-645 through 650 and V-AI-705, 706, 707 and A-AI-702, 703, 704). The heater reset button is located on the heater control board. Additional pressure protection is provided by pressure relief valves CV-708 through 713 and rupture discs which will relieve the contents of a trap to surge drum F-39 if the pressure rises above 50 psig.

When the liquid is drained, a sixth temperature point (TE-975 through 983) located on the liquid drain line from each trap is recorded to make sure that no plugging due to a low temperature will occur. This temperature is recorded on the sixteenth point of each Speedomax or Micromax recorder. A manual selector switch at the temperature recorder is used to connect the temperature element for the particular drain line temperature desired, since three drain lines are connected to a single point on the recorder.

Complete draining of the trap is indicated by weight indicators WI-905, 906 and 907 on the UF_6 cylinder scales.

(3) Cooling Cycle

Control of the cooling rate is accomplished by a manual adjustment of the needle valve which limits the rate of refrigerant flow to the cold trap. Careful control of the cooling rate is required during the early part of the cooling cycle to avoid undue strain on the traps. The rate must not exceed 5°F per minute at any of the temperature points on the cold trap. When the cold trap reaches minus 55°F, the bypass around the needle valve is opened to permit unrestricted refrigerant flow to the trap.

During the cooling cycle, pressures in the trap are equalized with those in the system through a choke in a line bypassing the process outlet block valve. This bypass is not opened until contents of the trap are below atmospheric pressure.

b. Weigh Tanks and Vaporizers

The weigh tank-vaporizer assembly consists of a UF_6 cylinder in a heated enclosure provided with an air circulating blower. The weigh tank vaporizers receive the liquid UF_6 from the cold traps and the product weights are indicated by WI-905, 906, 907. When the holding capacity of the vaporizer-cylinder is reached, the cylinder is heated and UF_6 vaporized to the cascade.

Control of the heat input is accomplished through PBM-908, 909, or 910 and PRC-911, 912, or 913 which actuate a relay PBS-917, 918, or 919 to maintain a temperature which will give the desired vaporizing pressure. PBS-914, 915, or 916 actuates alarms V-AI-999, 1000, 1001L to indicate high pressure in the vaporizers. The pressure is reduced by CV-923 (through PBM-920, PRX-921, and PBC-922) to maintain a constant pressure in the cascade feed line. An emergency switch TBS-1055, 1056, or 1057 is provided in case the temperature at the wall of the cylinder exceeds a preset value. This switch cuts off the heaters and actuates A-AI-1058 through 1060L and A-AI-1083 through 1085P.

The three vaporizer hoods are connected to an emergency ventilating system which will exhaust UF_6 to a scrubber tower F-41 in the event of a break. The scrubber tower is located on the ground floor near the cold trap framework. The tower is a cylindrical tank approximately two feet in diameter and seven and one-half feet high and constructed from Monel. There are two spray nozzles, one at the top of the unit and one about one-third of the way down from the top. The water is circulated through the tower by means of small centrifugal pumps. A sight glass is provided near the bottom of the tower to keep a check on the liquid level. In the event of a UF_6 break, vapor will be drawn into the top of the tower and down through the spray. The outlet from the tower connects to an ejector on the discharge side of a No. 25 Buffalo Blower with a capacity of 1600 cfm. The ejector has a discharge capacity of 3000 cfm, 1400 cfm from the scrubber and 1600 cfm from the blower. The blower and ejector are located near column lines D-10 on the mezzanine. The inlet to the blower is open to the room and the blower discharges through the ejector to a stack extending approximately ten feet above the roof of K-1131. There are three push button stations to start the emergency ventilation system; one station is located at each end of the cold trap framework and one station is located in the control room.

c. Blow Down Drum

The blow down drum is located outside K-1131 at the west end of the building. The drum is connected to the high pressure relief lines from all cold traps through header UG-43. If a cold trap relieves to the drum because of high pressure, the UF_6 will condense in the drum and remain there. The drum can then be emptied at any time by supplying it with heat through the steam coils fastened to its outside surface. The material in the surge is returned to process through UG-43 and RG-46 which is connected to the inlet of the three secondary cold traps.

If the pressure in a cold trap rises above 50 psig., relief valves CV-708, 709, 710, 711, 712, 720, 721, or 722 will open and the rupture discs will break to permit flow of gas to the blow down drum. The pressure in the relief lines is indicated on PI's-714 through 719 or 723, 724 and 725.

The pressure in the surge drum is controlled by CV-1168 located in RG-46 at 2.5 psig through DBM-1167. The pressure is indicated on PI-1166. If the control valve opens, PBS-1169 will actuate alarm V-AI-1170-P-12.

F. CO_2 Refrigeration System (Figure 30)

1. Flow

The CO_2 liquid coolant from the refrigeration room in K-402-9 flows into K-1131 in header CL-1 which branches into lines CL-26A, B and C leading to the tube side of the CO_2 heat exchangers 1, 2 and 3. The liquid CO_2 leaves the CO_2 heat exchangers through lines CL-27A, B and C, flows through header CL-4 and lines CL-32A and B to the float control valves. The liquid flows from the float control valves through lines CL-33A and B into the surge drums A and B. From the surge drums the liquid flows through lines CL-36A and B and CL-38 to header CL-3 which supplies the cold traps.

The CO_2 gas returns from the cold traps through headers CG-21A and B to line CG-63, which branches through lines CG-39A and B to the surge drums.

The gas flows out of the surge drums through lines CG-43A and B into header CG-5 which branches through lines CG-48A, B and C to the shell side of the CO_2 heat exchangers. The gas flows out of the heat exchangers through lines CG-45A, B and C into header CG-2 which returns the gas to the refrigeration room in K-402-9.

The surge drums are connected through relief valves in lines CG-58A and B to the vent header CG-44 which leads to the atmosphere. The heat exchangers are connected to the same vent header through relief valves located in lines CG-55A, B and C.

2. Control

The flow of CO_2 liquid to the surge drum is controlled by the float control valve on each drum. A liquid level instrument (DIM-1116 on drum A, DIM-1125 on drum B) indicates the level of the liquid in the drum. The DIM is connected to pressure switches which in turn sound alarms for high level, intermediate high level and low level. The intermediate switch also closes a solenoid valve in the CO_2 liquid inlet line. The following table gives the instrument numbers for each of the surge drums. All instruments are mounted on a panel between the surge drums.

TABLE

	High Level		Intermediate High Level		Low Level	
Drum A	PBS-1111	AI-1108	PBS-1112	AI-1109	PBS-1113	AI-1110
Drum B	PBS-1120	AI-1117	PBS-1121	AI-1118	PBS-1122	AI-1119

PI-1115 shows the pressure in surge drum A. PI-1124 shows the pressure in surge drum B.

V. PLANT OPERATING PROCEDURE

The operating procedure for the feed plant is divided into the following sections:

A. Feed, Product and Ash Handling
B. Plant Shakedown
C. Plant Start-Up
D. Normal and Emergency Shutdown
E. Preventive and Remedial Operation.

Part A describes the procedures to be followed for loading the UO_2 feed hoppers and for removing UF_6 product and UF_4 ash.

Part B describes the procedures to be followed to determine that all equipment and instruments are calibrated and operating properly.

Part C enumerates the normal positions and settings for all block valves, control valves, switches, temperature controllers, timers, etc. prior to plant start-up and then lists the steps, in sequence, to be followed to put the plant into operation.

Part D enumerates the steps, in sequence, to be followed for shutting down any part of the plant, for switching from one piece of equipment to its spare, and for shutting down one or more lines of the plant in the event of an emergency.

Part E lists the indications and possible causes of abnormal conditions which may occasionally be encountered in the operation of the feed plant, together with detailed statements of remedial, as well as preventive, measures which may be used to attain continuous, trouble-free operation. In analyzing the difficulties to be met in converting UO_2 to UF_6, and the removal of the product, emphasis has been placed on the control of temperatures, pressures, flows of reactants, and special mechanical problems directly related to the vibrating conveyors and their feeding mechanisms. Operation and maintenance of standard equipment (e.g., HF still, heat exchangers, gas compressors, etc.) are not treated.

For purposes of simplification, certain designations are employed as follows:

(1) Instrument numbers are followed by either the letter "L" (locally mounted) or the letter "P" followed by a number, designating location on a specific panel in the control room.

(2) The reaction line on the south side of the room is referred to as Line A, the middle line, Line B, and the line on the north side, Line C. Wherever identical items for identical functions, such as control valves, thermocouples, block valves, switches, alarms, etc., appear in each of the three lines, the numbers of the instruments in Line A are given first, Line B, second, and Line C, third.

(3) Block valves are identified by reference to equipment, pipe, or control valve to which they apply.

(4) Alarms for the plant are prefixed by the letter "A" where an audible alarm is used, or the letter "V" where a light is used.

A. Feed, Product And Ash Handling

1. UO_2 Powder Transfer (Figure 31)

a. Place a sealed drum in the cradle, roll the cradle into the dry box, close the dry box door and by working through the glove ports, remove the drum cover.

b. By use of the dry box hoist, lower the funnel adapter onto the drum and clamp securely in place using wing nuts to seal the funnel to the drum. Place the plastic cover over the open end of the funnel.

c. With the crane hook on the loop at the bottom of the cradle, invert the drum, lock it in position and observe joints and valve for dust leaks.

d. Remove the hook and roll the entire assembly out of the dry box.

e. By use of the building crane, raise the drum into position over the hopper to be filled; remove the plastic cover, lower drum into the dust seal, clamp in place, and open the vacuum cleaner.

f. Open the Gemco valve on hopper, then open the Gemco valve on the drum and note weight change in hopper to see that material is transferring. Tap the drum to knock down any loose powder.

g. After allowing dust to settle for a few minutes, close the Gemco valve on the funnel and then close the Gemco valve on the hopper.

h. Replace the plastic cover on the open funnel to prevent any dust from dropping and lower the drum, in the inverted position, into the dolly adjacent to the dry box.

i. Remove the crane hook and roll the dolly into the dry box.

j. Using the dry box hoist, invert the drum to the upright position, then remove the funnel adapter, and install the original cover.

k. Remove the dolly and drum from the dry box, and, using a drum sling, replace the empty drum with a full one, and repeat the above procedure.

2. Primary Cold Trap System

The design capacity of each primary cold trap matches a six-hour production rate from one vibrating tray reactor (ca. 750 pounds of UF_6). Therefore, for normal two-tray operation, two cold traps are "on-stream", two are going through the heating, draining and cooling cycle, and the remaining two are cold and in standby. Accordingly, when three trays are operating, the design calls for three cold traps to be "onstream" and the other three heating and cooling. Since this would leave no spare traps, this requirement may be modified if experience shows that two traps can adequately handle a six-hour three-tray production. Tests on cold trap holding capacity have indicated the latter possibility.

a. Condensing Cycle

Normal "onstream" cold trap operation requires the following observations:

(1) The length of time the cold trap is "onstream". The trap is taken "offstream" after a minimum of six hours (and a maximum of twelve)* trapping time provided no plug develops in this period.

(2) The outlet flow rate of each trap measured on PI-663 through 668. This flow rate indicates whether the cold trap is functioning normally. A drop in flow accompanied by an increase in flow in the other "onstream" trap indicates that the first trap is plugging and that its effective time "onstream" is reached. An audible alarm gives warning of the low flow and warns the operator to valve in another trap.

(3) The various shell and head temperatures and the outlet gas temperature. These temperatures are recorded on Speedomax charts. The outlet gas temperature gives indication of the cold trap operating performance. When a cold trap contains its capacity, another refrigerated trap is valved into the system and the full trap is taken "offstream" by closing the inlet and outlet valves. The heating cycle is then begun.

b. Heating Cycle

The isolated cold trap contains a charge of solid UF_6 and is at atmospheric pressure. In the heating cycle (3 to 3.5 hours), the trap and its contents are slowly heated from -55°F to a uniform temperature of 160°F to liquefy the UF_6. The liquid UF_6 is then drained to the vaporizers. Before the heaters are turned on, the trap is evacuated and the refrigerant lines are valved so that the CO_2 refrigerant can be blown from the cold trap lines.

The following procedure is used in heating a trap:

(1) Open block valve in evacuation line E-19A, B, C, D, E or F while the trap is at minus 55°F temperature.

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* A maximum value of twelve hours is set to minimize the possibility of overfilling the cold traps. (An overfilled trap may rupture when the UF_6 contents are liquefied since the volume of the liquid may be appreciably greater than that of the solid.)

(2) Allow valve to remain open for at least three minutes. This will permit evacuation of non-condensibles (N_2, O_2, F_2) from the trap.

(3) Close evacuation line valve.

(4) Make preparation for blowing refrigerant from the trap.

  (a) Close block valve which isolates the inlet refrigerant line (CL-42A, B, C, D, E, or F) from the liquid CO_2 header (CL-3).

  (b) Open valve in line (CG-41A, B, C, D, E, or F) which joins the inlet refrigerant line to the CO_2 vapor return header CG-21A.

  (c) Close valve in outlet refrigerant vapor line (CG-13, 14, 15, 16, 17 or 18) from the cold trap.

(5) Turn on internal shell calrod heater by throwing the appropriate switches on the heater control panel located at the cold traps.

(6) When the refrigerant is blown from the inner shell (as noted by a rise in temperature shown on TR-339 or 355), turn on the external shell calrod heater and the outlet head calrod tracing. Care should be taken to maintain the inner shell temperature above that of the outer shell to prevent distillation of UF_6 to the inner shell.

(7) Adjust calrod variacs to reduce the heating rate when the pressure approaches 27.5 psia (as read from PI-627, 628, 629, 630, 631 or 632). Should any temperature point on the trap exceed 180°F, or should the pressure exceed 35 psia, a relay will be tripped and all heaters will be cut off. An audible alarm will warn of this condition. Wait until the temperature and pressure return to normal before turning the heaters on again. A single switch at the heater board is provided for the entire heater circuit on one cold trap.

(8) When the pressure reaches 27.5 psia, the contents of the trap are liquid. The trap is then drained.

  (a) Open valve in the cold trap liquid drain line, UL-30A, B, C, D, E, or F.

  (b) Observe the increase in weight for the vaporizer receiving the cold trap product.

  (c) When transfer appears complete, determine from the trap "onstream" time whether the quantity drained agrees with the expected cold trap charge. If the weight agrees, close the drain line valve. If the weight is less than expected, check all temperature points. If any point shows less than 160°F, there is probably a solid UF_6 plug. If all temperature points appear correct, refer to "Preventive and Remedial Operation."

(9) The empty trap is ready for the cooling cycle.

c. Cooling Cycle

At the completion of the heating cycle the trap is at 27.5 psia and is at 160°F. In the cooling cycle, the trap is cooled to minus 55°F by evaporating CO_2, and gases are bled into the trap from the system to restore system pressure before the trap is returned to the process stream.

The following procedure is used in cooling a trap:

(1) Turn off inner shell, outer shell, outlet head and insertion heater calrods by pushing the "off" button on the heater control board. Leave the inlet head calrod tracing on.

(2) Set the refrigerant valves as follows:

(a) Open block valve in the outlet refrigerant vapor line CG-13, 14, 15, 16, 17 or 18.

(b) Close valve in the line CG-41A, B, C, D, E or F connecting the inlet refrigerant line CL-42A, B, C, D, E or F to the CO_2 vapor return header, CG-21A. The block valve in line CL-42A, B, C, D, E or F is closed. Close valves in lines CL-51A, B, C, D, E or F and bypasses supplying refrigerant to the inner shell.

(c) Open the block valve before the needle valve. The needle valve is already positioned to allow a maximum cooling rate of 5°F per minute to prevent undue stresses which might cause the trap to rupture. This maximum cooling rate must not be exceeded.

(d) When the trap pressure falls to 15 psia on PI-627, 628, 629, 630, 631 or 632, open the valves to the inner shell refrigerant lines CL-51A, B, C, D, E or F.

(e) When trap pressure falls below atmospheric pressure, open valve in the 1/4 inch line bypassing the outlet process gas block valve in line RG-12A, B, C, D, E or F. This operation permits gases from the system to bleed slowly into the trap during the cooling cycle. This valve must be open for at least twenty minutes.

(f) When trap temperature reaches minus 55°F, open block valve in line CL-42A, B, C, D, E or F and close block valve before the needle valve. Full flow of refrigerant is thus admitted to the trap.

(g) Close bypass valve around the outlet process gas line block valve. The trap is now at minus 55°F and one atmosphere pressure and is ready to be turned "onstream" when necessary. The total cooling cycle should take about two hours.

d. Placing Cold Trap "Onstream"

A trap cooled to minus 55°F is placed "onstream" to replace a full trap. The procedure consists of opening the gas inlet and outlet valves of the cooled trap and then closing the gas inlet and outlet valves of the full trap.

3. Secondary Cold Trap System

The secondary cold traps have a lower UF_6 load than the primary traps and thus have a larger effective "onstream" life. There are three traps provided, only one of which will be "onstream" at a time. Since the "onstream" time should be at least ten hours, the heating and cooling cycle schedule can be considerably more relaxed than for the primary traps. Otherwise, operating procedures are identical for those of the primary cold traps.

4. Vaporizer System

a. Filling Vaporizer From Cold Traps

(1) Weigh the UF_6 vaporizer cylinder with the pigtail disconnected from the manifold.

(2) Connect pigtail to connection on drain manifold.

(3) Close valve in air line connection to buffer between valves in line UL-32A, B or C.

(4) Open valve immediately before the pigtail connection on UL-32A, B or C.

(5) Evacuate pigtail and section of drain manifold by opening valve in evacuation line E-21A, B or C; when PI-1066 shows line is evacuated, close evacuation line valve.

(6) Open valve on UF_6 vaporizer cylinder.

(7) When cold trap is ready to drain, open drain line valve in line UL-32A, B or C.

(8) During draining of cold trap, take a sample of liquid UF_6 from SP-10A, B, C or D.

(9) When weight rise on WI-905, 906 or 907 stops, determine if calculated inventory of cold trap has drained.

(10) When inventory of a cold trap has drained, close drain line valve.

(11) When capacity of a vaporizer is reached, (maximum capacity 4,931 pounds)*:

*If a different type cylinder is substituted, do not fill to more than 3.08 times the water capacity.

(a) Close valve on cylinder and first valve in line UL-32A, B or C.

(b) Evacuate pigtail and section of drain manifold through the evacuation line E-21A, B or C.

(c) Close second block valve in line UL-32A, B or C.

(d) Open valve in air line connection to buffer between valves in line UL-32A, B or C.

(e) Disconnect pigtail from manifold.

(f) Record weight of UF_6 cylinder.

b. Vaporizing UF_6 to Cascade

(1) Check weight of UF_6 cylinder.

(2) Connect pigtail to cascade feed manifold UG-33A, B or C.

(3) Close valve in air line connection to buffer between valves in line UG-33A, B or C.

(4) Open first block valve in line UG-33A, B or C.

(5) Evacuate pigtail and section of manifold through E-36A, B or C by opening the evacuation line valve. When PRC-911, 912, or 913 shows line is evacuated, close evacuation line valve.

(6) Open valve on UF_6 cylinder.

(7) Start heaters and blower by pushing "on" button at vaporizer control panel.

(8) When pressure as read from PRC-911, 912 or 913 reaches 23 psia, the vaporizer is ready to go "onstream".

(9) Open second valve in UG-33A, B or C to cascade feed header UG-34.

(10) Record weight of vaporizer at regular intervals.

(11) When weight of UF_6 in cylinder drops to 400 pounds, shut down the empty vaporizer and valve in a full vaporizer.

(a) Turn off heaters.

(b) Close second valve in line (UG-33A, B or C) to cascade feed header.

(c) Open air louvres on vaporizer heater box.

(d) Close valve on UF_6 cylinder.

(e) Evacuate section of manifold and pigtail.

(f) Close first block valve in line UG-33A, B or C.

(g) Open valve in air line connection to buffer between valves in line UG-33A, B or C.

(h) Disconnect pigtail.

(i) Record weight of UF_6 cylinder.

5. Ash Receiver Handling (Figure 32)

a. Receiver Installation

(1) Place adapter over ash drum (a specially adapted 30 gallon feed drum) and install clamp ring.

(2) Move assembly into shield container and install shield cover securely.

(3) Install special cover on can adapter and pressure to 2.5 psig with air. Tighten shield cover until there is no detectable decrease in pressure in fifteen minutes and remove special cover.

(4) Remove grating over ash pit and lower receiver assembly into pit so that dolly will fit under the lifting flange. Position dolly around the flange and lower assembly the rest of the way.

(5) Open dry box doors and push dolly into dry box. When the wheels hit the stops, assembly will be directly under centerline of reactor flange. Gemco valves on the bottom of reactor must be closed.

(6) Turn handwheel at floor level approximately fifteen times until can hits the gasket and then turn wheel approximately 1/8 turn further to seal gasket. (The weight of ash receiver should be indicated on WI-956, 958 or 960).

(7) Open receiver to process by opening the two Gemco valves.

(8) Check periodically for evidence of leakage as shown by a white deposit of UO_2F_2 around the flange. If necessary tighten closure with handwheel.

b. Receiver Removal

(1) When receiver is full, close Gemco valves.

(2) Purge receiver free of UF_6 by alternately evacuating through line E-32A, B or C and pressuring through line N-20A, B or C.

(3) Lower assembly slowly with handwheel until screws hit stops.

(4) Open upper swinging door in the ash pit dry box, roll dolly to intermediate position in dry box, and place special cover on top of can neck.

(5) Roll dolly completely out of dry box and tighten special cover.

(6) Lift receiver 1/4 inch off the dolly and roll the dolly back toward dry box.

(7) Remove the receiver and shield assembly from pit and place on truck.

(8) Install empty receiver on reactor.

(9) Transfer full receiver in shield to designated storage area where shield is removed and returned to feed plant area for reuse. The procedure for removing the ash receiver from the shield at the storage area is as follows:

   (a) By use of a hoist, remove shielded receiver from truck and set it on the ground.

   (b) Remove cap screws holding shield cover to shield.

   (c) Place a sling under lifting lugs on the funnel adapter and lift receiver, with shield cover, out of shield and place on storage platform.

   (d) Remove sling from adapter and use it to lift shield cover from the ash receiver. The shield and its cover are now ready for return to the feed plant.

B. Shakedown Procedure

1. HF Recirculation System

Shakedown of the HF recirculation system is performed in three major steps, (a) testing of the nitrogen, purge, and water flush systems for each piece of equipment, (b) testing for the correct functioning of the process automatic pressure controls, (c) determination of flow continuity in the process piping.

a. Nitrogen, Purge, and Water Flush Systems

(1) Close all process and utility block valves (with exception of locked open valves).

(2) Set CV-1087 to give 2.5 psig in the main nitrogen header N-1 as indicated on PI-1088.

(3) Test the nitrogen purge to each piece of equipment by opening the inlet nitrogen valve and allowing the pressure to reach at least 1 psig. Close the nitrogen inlet valve and open the evacuation valve. If the pressure drops to atmospheric (as noted on the proper PI*), flow through the evacuation lines is indicated.

(4) Test the flow of nitrogen to each bellows connector by setting the pressure control valve on the appropriate buffer system panel to give 15" H_2O pressure in the header. Open the valve to each bellows and if the pressure suddenly drops and rises again, as noted on the proper PI, flow to the bellows buffering zone is indicated.

(5) Check for flow of nitrogen to the HF blower seals by setting PCV-1143 to give 1 psig as shown on PI-1147. Open the transfer cock to each blower seal and observe PI-1146 for evidence of flow through the seal.

(6) Test the water flush system to each piece of equipment by opening the water inlet and drain valves and allowing a small amount of water to flow through the equipment. Check for drainage through HFL-27 by opening the sample line SP-2. After completion of tests, all equipment must be drained. In conjunction with the water flush test on the still hold tank (H-9) the flow control valve (CV-968) should be tested for proper functioning, as follows:

*It will be necessary to test the purge and evacuation lines for the equipment not serviced individually by pressure indicating instruments (e.g., HF superheater) in conjunction with other items.

(a) Open the manhole located in the top of the tank and fill the tank approximately half full of water.

(b) Replace the manhole cover and open the block valve in the drain line HFL-16.

(c) Check the operation of CV-968 by setting valve positions on LIX-963. Check the operation of LBM-962 by observing the change in liquid level in the tank as indicated on LIX-963.

b. Automatic Pressure Controls

(1) HF Mixing Chamber (H-4)

(a) Admit nitrogen to the mixing chamber. When the pressure, as indicated on PRX-752, reaches 1.5 psig, CV-755, the vent relief valve, should open and AI-987 should be actuated. After the nitrogen is shut off, CV-755 should close.

(b) CV-753, the nitrogen relief valve, is set to open at minus 5" H_2O pressure. Since this pressure cannot be obtained in these tests, the valve must be reset to approximately 1/4 psig to check its functioning. Open the block valves around CV-753 and open the evacuation valve. When the pressure in the mixing chamber falls below 1/4 psig, as indicated on PRX-752, CV-753 should open and admit nitrogen. AI-985 will be actuated. Close the evacuation valve and note if CV-753 closes when the pressure reaches 1/4 psig.

(c) Reset CV-753 to minus 5" H_2O pressure and open the block valve between CV-754 and the mixing chamber. CV-754 should open. Admit nitrogen to H-4. When the pressure in H-4 rises to 13" H_2O pressure, CV-754 should close.

(2) HF Reactors (H-5A, B and C)

The flow control and pressure relief valves will be tested in conjunction with the fluorination reactors and will be described in section V-B-4.

(3) Sodium Fluoride Traps (H-13A and B)

Connect a portable pressure indicator to sample point SP-1 or SP-3. Admit nitrogen to the trap being tested through the purge line and when the pressure in the trap reaches 1.5 psig, the relief valve CV-1076 or 1078 should open. When the nitrogen flow is stopped, the pressure will drop and the control valve should close.

c. Determination of Continuity of Flow in Process Piping

(1) Open block valves and close bypass around the nitrogen inlet control valve CV-753.

(2) Open block valves around the HF relief valve CV-755.

(3) Close block valves and bypass valve around the HF feed valve CV-754.

(4) Open block valves and close bypass around the superheater.

(5) Open block valves on the inlets (upstream of flow and relief control valves) and outlets of the reactors, and close nitrogen purge valves.

(6) Open inlet and outlet valves to one partial condenser and close valves to the other condenser (to check one at a time).

(7) Close block valves and bypass valve around water control valve CV-749 to partial condensers.

(8) Close both drain valves from partial condensers.

(9) Close liquid outlet and drain valves on still feed tank.

(10) Open inlet and outlet valves to blower to be used and close valves around other blower.

(11) Close nitrogen and evacuation valves to blower inlets.

(12) Close block valves around NaF traps and HF purge valve CV-764.

(13) Close vent bypass valve between HFG-28A and HFG-24.

(14) Close valves in nitrogen and evacuation lines to mixing drum and superheater.

(15) Unless the loop in the still pot overflow contains liquid, or unless the normally locked open valve between the condenser and the blowers (in HFG-19) is closed, air may pass through the still and reflux condenser into (or out of) the recirculation system. If closing the valve is undesirable from a safety standpoint, during testing, the still pot may be filled with water through the water flush connection at the top of the still.

(16) Admit cooling water to the partial condensers.

(17) Turn on all equipment and piping heaters (follow reactor heat-up schedule as outlined in the Appendix - Section IX-C).

(18) Start nitrogen seal feed to blowers H-12A or B and start blowers.

(19) Adjust reactor pressure to atmospheric, admitting or venting N_2 as necessary.

(20) Observe the following:

(a) The various pressure and flow indicating and recording instruments for abnormally high or low valves.

(b) The functioning of temperature control instruments.

2. Dry Runs on Hydrofluorination Reactors

The mechanical functioning of each hydrofluorination reactor and UO_2 feed screw must be checked before test runs can be made to determine the proper settings for speed of operation and the timing cycle. The design conditions call for a cycle of "on" one minute - "off" fourteen minutes, and an average feed rate of 97 pounds UO_2 per hour, so that the screw and reactor transport the powder at a peak rate of 1455 pounds per hour. In order to save time in shakedown, andstill run under conditions which can be extrapolated to plant operation, the cycle may be shortened by a factor of 2 or 3. Since the UO_2 feed rate, under conditions encountered in the plant, will be directly proportional to the RPM of the screw flight, calibration at only one speed is necessary.

Visual observation of the powder movement in each reactor must be made to determine the minimum frequency of oscillation required for positive movement of powder. Pilot plant studies show this minimum speed to be approximately 650 RPM.

The dry run outlined below will determine the calibration of each UO_2 feed screw and the powder retention time on each tray reactor.

a. Settings:

(1) Turn on heat to the reactor and screw and adjust temperature to the conditions specified in section V-C.

(2) UO_2 feed screw RPM = 14.

(3) Tray drive RPM = the minimum frequency necessary for positive movement plus 50.

(4) Tray vibration and feed cycle = on one minute, off $6\frac{1}{2}$ minutes ($1:6\frac{1}{2}$ cycle) with the time delay relays set at five seconds. This cycle is the shortest that can be used with the right UO_2 screw speed.

(5) UF_4 feed screw RPM = 6.

(6) Fluorination tray drive RPM = 950.

b. Operation:

(1) Load three drums of UO_2 into the feed hopper. (See Section V-A for procedure to be used).

(2) Run the UO_2 feed screw and the hydrofluorination reactor on continuous operation for ten minutes. This procedure is necessary to insure filling the screw.

(3) Stop the UO_2 feed screw.

(4) Vibrate both reactors and run the UF_4 feed screw until there is no further increase in the weight of the ash receiver (i.e., the reactors are empty).

(5) Record the weight of the ash receiver.

(6) Start the UO_2 feed screw and the hydrofluorination tray on the intermittent cycle.

(7) Take readings of the UO_2 hopper weight at fifteen minute intervals.

(8) When the UF_4 hopper just begins to increase in weight, start the UF_4 feed screw and the fluorination tray, and adjust speed of screw to maximum to keep hopper empty.

(9) Take readings of the ash receiver weight at 15 minute intervals.

(10) Change ash receivers when the powder weight reaches 700 pounds (see Section V-A for procedure). Stop the UF_4 feed screw and the fluorination tray when changing ash receivers. Record the weight of each receiver.

(11) Stop the hydrofluorination tray and the UO_2 feed screw after 8 hours. Record the weight of the UO_2 hopper at this time.

(12) Stop the UF_4 feed screw and fluorination tray when there is no further increase in the weight of the ash receiver.

(13) Change ash receivers and record the weight of the powder removed from the system.

(14) Start the hydrofluorination tray on the intermittent cycle and run the UF_4 feed screw and fluorination tray continuously. Do not start the UO_2 feed screw.

(15) Run until there is no further increase in the weight of the ash receiver.

(16) Remove the ash receiver and record the weight of the powder removed from the system.

c. Evaluation Of The Dry Run

(1) The total weight of the powder removed from the trays will be the UO_2 feed rate for eight hours. As this run was made with a 1:6½ cycle, the feed rate was twice as great as the feed rate would be with a 1:14 cycle. Therefore, the weight of powder divided by sixteen equals the feed rate in pounds per hour for the 1:14 cycle.

(2) The UO_2 feed rate divided by 97 and multiplied by the observed screw RPM equals the correct screw RPM required for the plant feed rate (97 pounds per hour).

(3) The weight of the powder removed from the hydrofluorination tray divided by the UO_2 feed rate for the 1:14 cycle will give the powder retention time in hours for the design cycle.

(4) The record of the UO_2 hopper and ash receiver weights will show any irregularities in the feed to or from the tray. Channeling or bridging in the UO_2 hopper will cause erratic feeding to the tray; poor vibration will result in an irregular product rate.

d. Additional Dry Runs

If the powder retention time is determined to be between 3-1/2 and four hours on a 1:14 cycle, a twelve-hour run under identical conditions must be made. This run will serve as a test for gradual powder build-up on the tray and will also recheck the UO_2 feed rate. However, if the powder retention time does not fall in this range, additional eight-hour runs at other vibration frequencies must be made until the correct frequency is determined. This value must then be confirmed with a twelve-hour run as above.

3. HF Runs On Hydrofluorination Reactors

After the settings for a UO_2 feed rate of 97 pounds per hour, and a powder retention time of four hours have been determined by the dry runs, test runs using HF must be made. Several runs may be necessary to determine the minimum retention time required to produce a UF_4 assaying less than 1% UO_2 and to determine the temperature settings that will give a lump-free powder.

The procedure for the first run is outlined below:

a. Settings

(1) Tray and feed screw settings as determined from the dry runs.

(2) The conditions for operation are the same as those outlined for plant start-up, hydrofluorination system, on a 1:14 cycle.

(3) Fluorination tray temperature = 800°F.

b. Operation

(1) Load three drums of UO_2 into the feed hopper.

(2) Run the UO_2 feed screw and hydrofluorination tray continuously for ten minutes.

(3) Stop the UO_2 feed screw.

(4) Vibrate both trays and run the UF_4 feed screw until there is no further increase of weight in the ash receiver.

(5) Change ash receivers. Items (2) through (5) are necessary to fill the screw and may be omitted if the screw is already full.

(6) Start the hydrofluorination run as outlined in plant start-up.

(7) Take thirty-minute readings of the UO_2 hopper weight, the UF_4 hopper weight, the ash receiver weight, the tray temperatures, the inlet gas temperature, the temperature of the gas after the superheater, the temperature of the gas after the partial condenser, the system pressures and the gas flow.

(8) Follow normal operating procedure until the amount of powder in the UF_4 hopper is sufficient to start the UF_4 screw and reactor (100 pounds). Run UF_4 screw at 3 RPM and the fluorination reactor on continuous vibration. If necessary, adjust the UF_4 screw speed to keep a constant weight in the UF_4 hopper. This operation will then furnish calibration of the UF_4 screw under plant conditions.

(9) Change ash receivers after eight hours.

(10) Shut off all equipment after twelve hours and purge the trays for one hour.

(11) After the purge gas is turned off, take two samples of the powder in the UF_4 hopper and two samples from each ash receiver. These samples must be analyzed for total U, U^{+4}, fluoride and ammonium oxalate insolubles.

(12) Start vibration of the fluorination tray and run the UF_4 screw at 6 RPM. Run until there is no further increase of the weight in the ash receiver.

(13) Change ash receiver and record its weight.

(14) Start the hydrofluorination tray (on one minute, off $6\frac{1}{2}$ minutes), the fluorination tray, and the UF_4 feed screw (6 RPM). Run until there is no further increase of the weight in the ash receiver. Do not start the UO_2 feed screw. The weight of powder removed in this step will be the weight of the powder remaining on the hydrofluorination tray.

c. Evaluation Of The Run

(1) The UO_2 feed rate will be calculated by dividing the total weight of the powder (corrected to UO_2) by the length of the run.

(2) The retention time will be calculated by dividing the weight of the powder on the hydrofluorination tray (corrected to UO_2) by the feed rate.

(3) The % unreacted UO_2 = % A.O.I. (ammonium oxalate insoluble).

(4) The % U^{+6} = total U - U^{+4}.

(5) The % UO_2F_2 = % U^{+6} x 1.29.

(6) The % UF_4 may be determined in two ways -

(a) % UF_4 = (% F - % U^{+6} x 0.16) x 4.13

(b) % UF_4 = (% U^{+4} - % A.O.I. x 0.88) x 1.32

(7) The amount of lumping is estimated by visual inspection of the UF_4 product.

d. Additional HF Runs

If the powder assays more than 1% UO_2, the retention time or the temperatures, or both, must be increased. If lumping or caking occurs, the temperatures must be decreased (see Preventive and Remedial Operation).

The effects of temperature and retention time on the conversion efficiency are described in the Quarterly Reports listed in the Appendix, (Section IX-A).

4. Fluorine Recirculation System

Shakedown of the fluorine recirculating system is performed in three major steps as follows: (a) testing of the purge and evacuation systems; (b) testing of the operation of the automatic pressure controls; and (c) determination of the continuity of flow in process piping.

a. Purge and Evacuation Systems

(1) Close all valves on process and utility lines (with the exception of locked open valves).

(2) Set CV-1070 to control the water temperature at 110°F in header W-5.

(3) Open water inlet and outlet lines to vacuum pump (F-21).

(4) Open pump discharge valve, and inlet and outlet valves on alumina trap (F-20).

(5) Close bypass valve around alumina trap.

(6) Turn on vacuum pump.

(7) Pressure the following pieces of equipment to nitrogen line pressure:

Primary Compressors F-4A and B
Secondary Compressors F-8A and B
Primary Coolers F-3A and B.

(8) Open block valve between headers E-1 and E-24.

(9) Open the appropriate evacuation valve on each piece of equipment listed in (7) separately and check evacuation on PI-1066.

(10) With all evacuation valves to the above equipment open, turn pump off and pressure equipment to atmospheric pressure.

(11) Close block valve between headers E-1 and E-24.

(12) Test the flow of nitrogen to each bellows connector by setting the pressure control valve on the appropriate buffer system panel to give 15" H_2O pressure in the header. Open the valve to each bellows-if the pressure suddenly drops and rises again, as noted on the proper PI, flow to the bellows buffering zone is indicated.

(13) Check for flow of air to the fluorine compressor seals by setting PCV-1144 and 1163 to give 1 psig as shown on PI-1159 and PI-1153. Open the transfer cock to each seal feed connection on each of the four compressors and observe PI-1158 and 1152 for evidence of flow through each seal.

(14) Testing of the purge and evacuation system for the rest of the fluorination plant equipment will be carried out in conjunction with testing of the automatic pressure controls.

b. Automatic Pressure Controls

(1) Hydrofluorination and Fluorination Reactors

(a) Close block valves in HFG-8 and bypass, and HFG-10A, B and C.

(b) Open block valves around evacuation control valve CV-1068.

(c) Start vacuum pump. Observe the pressure on PI-1066 when CV-1068 closes. It should be 5" Hg. vacuum.

(d) Set the pressure relief valves (CV-772, 792, 812, 841, 858 and 875) to relieve at minus 2 psig and plus 2 psig by means of the appropriate pressure blind switches.

(e) Open nitrogen inlet valve from line N-17 to each reactor line until the pressure is 1 psig, then close valve.

(f) Open nitrogen inlet valve in line N-13 until the above relief valves open as indicated by the actuation of high pressure alarms AI-769, 789, 809, 838, 855 and 873.

(g) Open the evacuation block valves in header E-20A, B or C and pump on the reactor until the relief valves listed above open as indicated by the actuation of low pressure alarms AI-770, 790, 810, 839, 856 and 872.

(h) Pressure reactors to atmospheric pressure by opening the nitrogen block valves from header N-17 to each reactor.

(2) Mixing Chamber

(a) Set PIX-942 on proportional control, and adjust to control at fifteen inches H_2O.

(b) Open block valves around CV-939, system pressure control valve, high pressure relief valves CV-944 and 945, and bypass around alumina traps (F-22A and B).

(c) When the pressure in the mixing chamber reaches six inches as shown on PRX-936, low pressure relief valve CV-943 should close, and alarm AI-1009 will turn off.

(d) Slowly admit nitrogen to the mixing chamber through the block valve in line N-8. When the pressure reaches 1 psig, PBS-937 should open CV-939. Immediately after CV-939 opens, CV-944 and 945 should open, and alarm AI-1007 will be actuated.

(e) Close nitrogen inlet valve to the mixing chamber. Observe (1) the pressure on PIX-942 at which CV-944 closes as indicated by AI-1007 turning off, and (2) the pressure at which CV-945 closes as shown by loss of flow on PI-948.

(3) NaF Traps

(a) Open nitrogen inlet valves in lines N-12A and B to the NaF traps F-10A and B, and observe whether the relief valves CV-1080 and 1082 open.

(b) Open outlet block valves to stack in lines RG-26A and B to return the NaF traps to atmospheric pressure. CV-1080 and 1082 should close.

c. Determination of Continuity of Flow in Process Piping

(1) Turn on all equipment and piping heaters (follow reactor heat-up schedule as outlined in the Appendix - Section IX-C).

(2) Close all nitrogen purge and evacuation block valves.

(3) Open block valves on the inlets (upstream of flow and relief control valves) and primary and secondary outlets of the reactors.

(4) Open inlet and outlet valves around one primary and one secondary compressor and close valves to the other two (to check one at a time).

(5) Open block valves around compressor recycle control valves CV-927 and 897.

(6) Open water inlet valves to the primary and secondary gas coolers.

(7) Open inlet and outlet valves around one primary and one secondary cold trap and close valves on other traps (to check one trap at a time).

(8) Open inlet and outlet valves around the NaF traps.

(9) Block valves around the pressure control valve, CV-939, the high pressure relief valves, CV-944 and 945, and the vacuum relief valve CV-943 are already locked open; close the block valves in the bypasses around CV-939 and CV-943.

(10) Close block valves in the liquid drain lines from all cold traps.

(11) Close block valves in the lines between the NaF traps and the vent line.

(12) Close block valves and bypass valve around the fluorine inlet control valve, CV-955.

(13) Open manually operated flow control valves, CV-834, 851 and 868 in the reactor inlet lines.

(14) Start air seal feed to the primary compressor F-4A or B and start compressor. After compressor is started, adjust seal feed pressure to 1/4 to 1/2 pound above process pressure.

(15) Set PIX-942 on proportional control and adjust to control system pressure upstream of the pressure control valve CV-939 at 15" H_2O.

(16) Open manually operated flow control valves, CV-828, 845 and 862 in the secondary recycle lines.

(17) Start air seal feed to the secondary compressor F-8A or B and start compressor. Adjust seal feed pressure and flow.

(18) Observe the following:

(a) The various pressure and flow indicating and recording instruments for abnormally high or low values.

(b) The functioning of temperature control instruments.

5. Dry Runs on Fluorination Reactors

UF_4 made by Mallinckrodt will be used to check the functioning of each fluorination tray and UF_4 feed screw. The UF_4 will be charged to the UO_2 feed hopper and will be preheated on the hydrofluorination tray. The following procedure will be used:

a. Settings:

(1) The hydrofluorination tray temperatures will be the same as those required in the HF step (see Plant Start-Up, Section V-C).

(2) The fluorination tray temperatures will be the same as those required in the F_2 step (see Plant Start-Up, Section V-C).

(3) UO_2 feed screw RPM = 19.

(4) Hydrofluorination tray drive RPM = the minimum required for powder movement plus 50.

(5) Hydrofluorination tray drive and UO_2 feed cycle = 1:14, with the time delays set at five seconds.

(6) UF_4 feed screw RPM = 3.

(7) Fluorination tray drive RPM = 950.

b. Operation:

(1) Charge 1200 pounds of UF_4 to an empty UO_2 feed hopper. (Refill as required.)

(2) Run UO_2 feed screw and hydrofluorination tray continuously for three minutes.

(3) Start UO_2 feed screw and hydrofluorination tray on the intermittent cycle.

(4) Record the UO_2 hopper weights at thirty-minute intervals.

(5) When the UF_4 hopper weight has increased 150 pounds, start the UF_4 screw and fluorination tray.

(6) Record the ash receiver weights every thirty minutes.

(7) Adjust the UF_4 feed screw RPM to keep a constant weight in the UF_4 hopper.

(8) After the UF_4 hopper weight has been held constant for one hour, make a one-hour check of the feed rate.

(9) If the feed rate is not 114 pounds/hour, adjust the RPM of the UO_2 feed screw in the following manner:

RPM x 114/feed rate = the correct setting.

(10) Synchronize both screws at the feed rate of 114 pounds/hour of UF_4, and make a four-hour check of the feed rate taking UO_2 hopper and ash receiver weights every 30 minutes as in Section V-B-2.

6. F_2 Runs on Fluorination Reactors

a. Check of The Conversion in The Reaction Section

Start the F_2 run immediately after the dry run so that the temperature of the powder in the intermediate hopper will not be lowered appreciably. (See Preventive and Remedial Operation.)

The first run will last twelve hours and will follow the plant start-up procedure for the primary recycle system. Instead of passing 10% of the flow over the cleanup section, the bleed gas will be taken through the bypass line (RG-40) and the flow will be indicated by the reading on PI-689.

After twelve hours, the run must be stopped (see Normal Shutdown Procedure) and the tray purged. The ash must be weighed and the tray must be checked for evidence of caking. Attempts should be made (by visual observation) to get a qualitative picture of the distribution of any cake remaining on the tray before it is scraped off and weighed.

Refer to "Preventive and Remedial Operation" if excessive caking or poor conversion of UF_4 to UF_6 is found in the test run. Alter conditions accordingly and repeat the twelve-hour runs until satisfactory results are obtained.

b. Check of The Efficiency of The Cleanup Section

After the optimum conditions for the UF_4 to UF_6 reaction are determined by the preceding runs, the efficiency of the clean-up section must be checked. This run will also last for twelve hours and will follow the "Plant Start-Up Procedure". After twelve hours the results must be examined as in the preceding runs and the conditions corrected if necessary. (See "Preventive and Remedial Operation" - Section V-E).

C. Plant Start-Up

1. Hydrofluorination System - Conditions

Close all nitrogen purge, water flush, evacuation, and sample valves. Turn on all line heaters. The following valves must be locked open:

NaF traps (H-13A and B) relief block
Reflux condenser (H-11) gas outlet
Reflux condenser (H-11) water outlet
Partial condensers (H-7A and B) water outlet
CV-755 inlet and outlet block
Superheater (H-3) inlet and outlet block
Azeotrope cooler water outlet
Distillation column (H-10) overflow
HF reactors (H-6A, B and C) relief block.

a. Mixing Chamber (H-4)

(1) Set PBS-984-P-8 to open low pressure relief valve CV-753 (line N-23) at minus 5" H_2O. A-AI-985-P-8 will operate when CV-753 opens.

(2) Open block valves on either side of CV-753.

(3) Close bypass valve around CV-753.

(4) Set PBS-986-P-8 to open high pressure relief valve CV-755 (vent line) at plus 35" H_2O. A-AI-987-P-8 will operate when CV-755 opens.

(5) Open block valves on either side of CV-755.

(6) Set PRX-752-P-8 to open HF inlet control valve CV-754 (line HFG-5) at approximately atmospheric pressure.

(7) Close block valves on either side of CV-754.

(8) Close bypass valve around CV-754.

b. HF Superheater (H-3)

(1) Set the shell temperature of the superheater on TBS-757-L at 650°F.

(2) Open block valves on either side of the superheater, (line HFG-6).

(3) Close bypass valve around the superheater (line HFG-6).

(4) Turn on heaters.

c. <u>HF Preheaters (H-5A, B, C)</u>

(1) Set TIC-439-P-6, 440-P-6, and 441-P-6 at 1000°F.

(2) Turn on heaters.

d. <u>Hydrofluorination Trays (H-6A, B, C)</u>

(1) Set tray pressure relief valves (CV-772, 792, 812) to open at plus 2.5 psig and minus 2.5 psig.

(a) Set PBS-768-L, PBS-788-L and PBS-808-L at plus 2.5 psig.

(b) Set PBS-996-L, PBS-997-L and PBS-998-L at minus 2.5 psig.

(2) Turn on heat to furnaces. Follow heating schedule shown in Section IX-C.

(3) Set furnace temperatures as follows:

(a) Zone 1. 750°F.

A Reactor-TIC-412-P-2, TIC-415-P-2
B Reactor-TIC-413-P-2, TIC-416-P-2
C Reactor-TIC-414-P-2, TIC-417-P-2

(b) Zone 2. 850°F.

A Reactor-TIC-418-P-3, TIC-421-P-3
B Reactor-TIC-419-P-3, TIC-422-P-3
C Reactor-TIC-420-P-3, TIC-423-P-3

(c) Zone 3. 950°F.

A Reactor-TIC-424-P-4, TIC-427-P-4
B Reactor-TIC-425-P-4, TIC-428-P-4
C Reactor-TIC-426-P-4, TIC-429-P-4

(d) Zone 4. 1050°F.

A Reactor-TIC-430-P-5, TIC-433-P-5
B Reactor-TIC-431-P-5, TIC-434-P-5
C Reactor-TIC-432-P-5, TIC-435-P-5

(4) Set the on-off cycle and the vibrator RPM to give a four-hour retention time as determined by shakedown runs.

e. <u>UO_2 Feed Hoppers (H-17A, B, C)</u>

(1) Set the low powder level cut-off switches, PBS-780-P-9, PBS-800-P-9, and PBS-820-P-9 and the low level alarm switches PBS-969-L, PBS-971-L, PBS-973-L at 300 pounds.

(2) Close Gemco loading valve on the feed hopper.

(3) Open the slide gate.

f. UO_2 Feed Screws (H-31A, B, C)

(1) Set TIC-436-P-6, TIC-437-P-6 and TIC-438-P-6, at 700°F.

(2) Set the screw drive to deliver 97 pounds UO_2/hour as determined by the shakedown runs.

(3) Turn on heaters.

g. HF Partial Condenser (H-7A, B)

(1) Set TIX-748-P-8 to control the flow of cooling water through CV-749 (line W-25) in order to maintain an exit gas temperature of 185°F.

(2) Open block valves on either side of CV-749.

(3) Close the bypass valve around CV-749.

(4) Open block valves on either side of the condenser to be used, (line HFG-13A or B and line HFL-14A or B).

(5) Close block valves on either side of the spare condenser, (line HFG-13A or B and line HFL-14A or B).

(6) Open block valve in water inlet (line W-12A or B) to the condenser in use. Close the corresponding valve in the line to the spare condenser.

h. Recirculating Gas Blowers (H-12A and B)

(1) Open block valves on either side of the blower to be used (lines HFG-22A or B and HFG-23A or B).

(2) Close block valves on either side of the spare blower (lines HFG-22A or B and HFG-23A or B).

(3) Turn on nitrogen to pump seals and set pressure at 1 psig (PI-1147-L). This pressure may be adjusted during operation to 1/4 to 1/2 psi above process pressure.

(4) Turn on pump casing heaters.

i. Hold Tank (H-9)

(1) Close drain valves (line HFL-26).

(2) Close block valves (line HFL-16) to the distillation column (H-10).

(3) Close block valve on the bypass line connecting HFL-26 to HFL-16.

j. <u>HF Still (H-10); Reflux Condenser (H-11); Azeotrope Cooler (H-14)</u>

(1) Fill the still reboiler and liquid leg seal with water.

(2) Close the following valves:

(a) Control valve CV-968 (line HFL-16).

(b) Block valve in bypass around liquid leg (line HFL-27).

(3) Open the following block valves:

(a) Water inlet (line W-22) to azeotrope cooler.

(b) Water inlet (line W-11) to reflux condenser.

(c) Downstream of CV-968 (line HFL-16).

(4) Set TIX-744 so that the reflux condenser gas outlet temperature is controlled at 185°F.

k. <u>NaF Traps (H-13A and B)</u>

Each trap has a capacity of approximately 44 pounds of HF when operated at conditions shown on the process flow sheet. This capacity corresponds to an adsorption period of approximately 11 hours.

(1) Set trap relief valves (CV-1076, 1078) at 1.5 psig.

(2) <u>Adsorption Cycle</u>

During normal operation one of the traps will be used for adsorption while the other trap is being regenerated. The trap being regenerated is referred to as the spare trap.

(a) Open block valves on either side of bleed control valve CV-764 (line HFG-28). Close bypass.

(b) Set the HF analyzer, XX-1222, to open CV-764 when the inerts concentration increases above 5%.

(c) Open inlet block valve on the NaF trap to be used (line HFG-11A or B).

(d) Close inlet block valve on the spare trap (line HFG-11A or B).

(e) Open vent block valve from the trap to be used, (line HFG-34A or B).

(f) Close outlet block valve (line HFG-30A or B).

(g) Close NaF trap bypass valve (line HFG-28A).

(h) Set temperature controller TBS-758 or 759 at 200°F.

(i) Turn on heaters.

(3) Regeneration Cycle

The trap adsorbing is referred to as the spare trap.

(a) Close inlet block valve to the trap to be regenerated (line HFG-11A or B).

(b) Close vent block valve (line HFG-34A or B).

(c) Open outlet block valve (line HFG-30A or B).

(d) Set temperature control switch TBS-758-L or 759-L at 900°F.

1. Bellows

(1) Turn on the N_2 buffer to all bellows and check for leaks.

(2) Set bellows buffer pressure at 1/2 psig as read on PI's-1103, 1104, 1105, 1106 and 1107.

2. Hydrofluorination System - Start-Up

a. Start-Up of a Reactor Line

If one or more lines are already in operation, omit steps 3 and 6 below. Close all inlet and outlet block valves to both reactors in lines which are either shut down or being started up.

(1) Transfer three drums of UO_2 (approximately 800 pounds/drum) to the feed hopper.

(2) Start the UO_2 screw conveyor, H-31A, B or C, and allow it to run for approximately three minutes. The conveyors are started and stopped independently of the reactor vibrators by pushing the proper start or stop button located on the reactor support framework near the drive unit.

(3) Start HF recirculating gas blower, H-12A or B. The start-stop buttons for the blowers are located near the blower stands.

(4) Open hydrofluorination reactor outlet block valves.

(5) Start reactor vibrator and screw conveyor by pushing the "Normal Start" button located near the drive units on the reactor support framework. This will start the conveyor and vibrator on the intermittent cycle. Allow reactor to go through one "on" cycle before the next step.

(6) Open block valves around HF feed valve CV-754 (line HFG-5). The system is now open to the HF vaporizers in the fluorine plant.

(7) Open reactor inlet block valve (line HFG-9A, B or C) and adjust inlet control valve CV-776, 796, or 816 to hydrofluorination reactor so that the pressure indicator PIX-775-P-9, 795-P-9, or 815-P-9 shows a flow of 160 pounds of HF per hour.

(8) When the UF_4 feed hopper (F-14A, B or C) contains 150 pounds of powder, (as noted on WI-782, 802, 822) start UF_4 screw conveyor (F-15A, B or C) and run for three minutes at 3 RPM to fill the UF_4 screw. The start-stop buttons for these conveyors are located on the hydrofluorination reactor framework near the UF_4 feed hopper.

(9) Purge HF from the fluorination reactor (F-2A, B, or C) according to the procedure outlined in Section VI.

b. <u>Start-Up of HF Still</u>

If still already contains liquid, omit steps 2 and 3 below.

(1) Turn on the heat to still column and reboiler.

(2) Open control valve CV-968 by means of LIX-963-P-8.

(3) Close CV-968 when level in hold tank drops approximately 20 gallons.

(4) Set TRX-738-P-8 to maintain still reboiler at 230°F. The number of heaters used to maintain the temperature of the reboiler is manually controlled by XX-739-P-7.

(5) Allow still to heat up and reach equilibrium.

(6) Open and adjust control valve CV-968 to maintain a constant level in hold tank as shown on LIX-963-P-8.

3. <u>Fluorination System - Conditions</u>

Close valves on all N_2 purge, evacuation, and sample lines. Turn on all line heaters. The following valves must be locked open:

Secondary cooler (F-7A, B and C) water outlet

Primary Cooler (F-3A and B) water outlet
CV-939 inlet and outlet block
CV-1080 outlet block
CV-1082 outlet block
CV-943 inlet and outlet block
CV-944 inlet and outlet block
Fluorine reactor (F-2A, B and C) relief block
Cold trap process relief block
Cold trap refrigerant relief block
CV-1168 inlet and outlet block
CO_2 heat exchangers relief inlet and outlet block
CO_2 surge drum "A" relief inlet and outlet block
CO_2 surge drum "B" relief inlet and outlet block
Freon condenser relief inlet and outlet block
Cold trap CO_2 gas relief inlet and outlet block
Cold trap CO_2 liquid relief inlet and outlet block
F-39 gas inlet
Nitrogen header relief block.

a. Fluorination Reactor (F-2A, B, C)

(1) Set pressure relief valves CV-841, 858 and 875 as follows:

A Reactor (CV-841)

PBS-837-L plus 2.5 psig
PBS-781-L minus 2.5 psig

B Reactor (CV-858)

PBS-854-L plus 2.5 psig
PBS-801-L minus 2.5 psig

C Reactor (CV-875)

PBS-871-L plus 2.5 psig
PBS-821-L minus 2.5 psig

(2) Turn on heat to furnaces, follow heating schedule shown in Section IX-C.

(3) Set the furnace temperatures as follows:

Zone 1. 800°F.

A Reactor-TIC-460-P-2, TIC-463-P-2
B Reactor-TIC-461-P-2, TIC-464-P-2
C Reactor-TIC-462-P-2, TIC-465-P-2

Zone 2. 900°F.

A Reactor-TIC-466-P-3, TIC-469-P-3
B Reactor-TIC-467-P-3, TIC-470-P-3
C Reactor-TIC-468-P-3, TIC-471-P-3

Zone 3. 950°F.

A Reactor-TIC-472-P-4, TIC-475-P-4
B Reactor-TIC-473-P-4, TIC-476-P-4
C Reactor-TIC-474-P-4, TIC-477-P-4

(4) Set reactor vibrator at the RPM determined by shakedown runs.

(5) Close inlet block valve to reactor (line FG-4A, B or C) and open wide CV-834, 851 or 868 through PRX-833, 850 or 867.

(6) Open primary outlet block valve (line UG-5A, B or C).

(7) Open bypass block valve (line RG-40) and close secondary outlet block valve (line RG-15A, B or C). If a line is operating, do not open block valve in RG-40.

b. Primary Coolers (F-3A and B)

(1) Open gas inlet block valve (line UG-7A or B) to primary cooler to be used, and close corresponding valve to spare cooler.

(2) Open gas outlet block valve (line UG-8A or B) from primary cooler to be used and close corresponding valve to spare cooler.

(3) Set water temperature control valve CV-1070 to give water temperature of 120°F as indicated on TI-1069L.

(4) Open water inlet block valve (line W-8A or B) on primary cooler to be used and close corresponding valve to spare cooler.

c. Primary Gas Blowers (F-4A and B)

(1) Turn on air to blower seals. Adjust pressure (PI-1158-L) to 1/4 psi above process pressure.

(2) Open inlet block valve (line UG-9A or B) and outlet block valve (line UG-10A or B). Close corresponding valves on spare blower.

(3) Pressure relief valves CV-1003, on blower A, and CV-1005, on blower B, are set to open at 2 psig.

(4) Set pressure controller PRX-895-P-11 to control tray pressure at 0 psig.

(5) Open block valves around CV-897 and close bypass valve.

(6) Turn on pump casing heaters.

d. Cold Traps (F-5A through 5F)

(1) Cool two traps to -55°F. See Section V-A.

(2) Open inlet block valve (line UG-11) and outlet block valve (line RG-12) on the cold traps.

(3) Close 1/4" bypass valve (line RG-12).

(4) Close inlet and outlet valves on spare traps.

e. Secondary Coolers (F-7A, B and C)

(1) Open water inlet block valves (lines W-10A, B and C).

f. Secondary Blowers (F-8A and B)

(1) Turn on air to blower seals; adjust pressure as indicated on PI-1153-L to 1/4 psi above process pressure.

(2) Open inlet block valve (line RG-18A or B) and outlet block valve (line RG-19A or B).

(3) Pressure relief valves CV-1072, blower F-8A, and CV-1074, blower F-8B, are set to open at 3 psi.

(4) Set pressure controller PRX-926-P-10 (line RG-16) at plus 2" H_2O.

(5) Open block valves around CV-927 and close bypass valve.

(6) Close block valves on spare blower.

(7) Turn on pump casing heaters.

g. Secondary Cold Traps (F-9A, B, C)

(1) Cool one trap to -55°F. See Section V-A.

(2) Open inlet block valve (line RG-21) and outlet block valve (line RG-22).

(3) Close 1/4" valve in bypass line around RG-22.

h. NaF Traps (F-10A and B)

Each trap has a capacity of approximately 44 pounds of HF. This capacity will correspond to an adsorption period of about 3 days at plant conditions shown on process flow sheet.

(1) Set NaF trap relief valves CV-1080 and 1082 to open at 1.5 psig.

(2) Adsorption Cycle:

For the trap adsorbing,

(a) Open inlet block valve (line RG-24A or B).

(b) Open outlet block valve (line RG-25A or B).

(c) Close vent block valve (line RG-26A or B).

(d) Set temperature switch TBS-951 or 952 at 200°F.

(e) Close inlet and outlet block valves on spare trap if it is not regenerating.

(f) Turn on trap heaters.

(3) Regeneration Cycle:

For the trap regenerating,

(a) Close inlet block valve (line RG-24A or B).

(b) Close outlet block valve (line RG-25A or B).

(c) Open vent block valve (line RG-26A or B).

(d) Set temperature switch TBS-951 or TBS-952 at 900°F.

(e) Close inlet and outlet block valves on spare trap if it is not adsorbing.

i. Alumina Traps (F-22A and B)

(1) Open block valves around pressure relief control valve CV-945 (line RG-29).

(2) Lock open inlet and outlet block valves to trap F-22A or B (line RG-37A or B and RG-38A or B), and close block valves on spare trap.

(3) Close bypass valve around the traps.

(4) Set pressure indicating controller PIX-942-P-11 on automatic reset so that CV-945, CV-944 and CV-943 will control at approximately 15" H_2O pressure.

(5) Set PBS-1006-L so that A-AI-1007-P-11 will sound when control valve CV-943 opens. Set PBS-1008-L so that A-AI-1009-P-12 will sound when control valve CV-944 opens.

(6) Set pressure controller PRX-936-P-11 to control mixing chamber pressure at 8" H_2O.

(7) Open block valves around secondary recycle control valve CV-939 and close bypass valve.

(8) Set PBS-937 to open CV-939 when the pressure in mixing drum reaches 1 psig.

j. F_2 Gas Analyzer

(1) Set concentration recorder CRX-967-P-11 so that control valve CV-955 (line FG-1) maintains the fluorine concentration in the gas stream at 25 mol. percent.

k. Ash Receivers (F-13A, B, C)

(1) Attach ash receiver in its shield to the bottom of the reactor as described in Section V-A.

(2) Open the two Gemco valves connecting the ash receiver to the fluorination reactor.

l. Utilities

(1) Set CV-1087 (line N-34) to maintain nitrogen pressure at 2.5 psig.

(2) Set CV-1062 (line A-12) and CV-1064 (line A-2) to maintain air pressure for cold traps and instruments at 40 psig.

(3) Set CV-1068 through DBM-1067 to limit vacuum in reactors during evacuation cycle to 5" Hg.

(4) Open block valves and close bypass valves around CV-1062, 1064, 1068 and 1087.

4. Fluorination System - Start-Up

If one or more reactor lines are already in operation, omit steps d, f and h.

a. Start up vibrator and screw. Run until a small amount (approximately 5 pounds) of powder is in the ash receiver.

b. Open block valve adjacent to F_2 inlet control valve, CV-834, CV-851 or CV-868.

c. Open outlet block valve (line UG-5A, B or C).

d. Start primary recycle F_2 blower, F-4A or B. Start-stop button is located near the blowers.

e. Adjust control valve, CV-834, CV-851 or CV-868 using pressure recorder PRX-833-P-10, PRX-850-P-10, or PRX-867-P-10 to give a flow of 40 cfm to each reactor.

f. Open the block valves around CV-955 (line FG-1).

g. With CV-955 on manual control, slowly admit F_2 to the system; when the concentration of F_2 as recorded by CRX-967-P-11 is approximately 25 mol. percent, place the valve on automatic control.

h. Start secondary recycle blower, F-8A or B. Start-stop buttons are located near the blowers.

i. When equilibrium conditions are reached, open block valves adjacent to control valves, CV-828, 845, or 862 in the secondary recycle (line RG-15A, B, or C). Close bypass block valve (line RG-40). Manually set PIX-827, 844 or 861 to approximately 10% of the reactor inlet flow.

D. Shutdown Procedure

The shutdown procedure for the feed plant is given for three different cases: (1) emergency shutdown from the control room only, (2) normal shutdown of one line of reactors and switching of spared auxiliary equipment, and (3) normal shutdown of HF and F_2 gas recycle systems. The procedure for purging and flushing equipment is given in Section VI.

1. Emergency Shutdown

Emergency shutdown of the plant from the control room may be necessary in the case of a serious break in the feed or fluorine plants. The procedure is as follows:

a. Turn on emergency ventilation.

b. Close the control valve CV-754 on the HF supply line by means of PRX-752.

c. Close the control valve CV-955 on the F_2 supply header through CRX-967.

d. Stop the motors on the UO_2 screws and hydrofluorination reactors.

e. Stop the motors on the UF_4 screws and fluorination reactors. After performing these operations, as soon as it is possible to reach the operating floor, stop the motors on the F_2 and HF blowers and close the inlet and outlet block valves on the cold traps onstream.

2. Normal Shutdown of a Reactor Line and Switching of Spared Equipment

Normal shutdown of one reactor line and switching of spared equipment will be carried out while the rest of the equipment is still in operation.

a. Normal Shutdown of a Line (Hydrofluorination and Fluorination Reactors

(1) Hydrofluorination Trays (H-6A, B or C)

(a) Shut slide gate in UO_2 feed hopper.

(b) Allow screw conveyor and tray to run dry of powder, under normal operating conditions.

(c) Slowly close block valve in HF inlet line, HFG-9A, B or C and turn off HF preheater H-5A, B or C.

(d) Close block valve on reactor outlet line, HFG-10A, B or C.

(e) Turn off screw and vibrator reactor motors.

(f) Purge reactor tray of HF gas.

(g) For short down times (e.g., changing bellows, gaskets, packing) powder may be left in screw and on tray. (Follow steps c, d, e, and f above.)

(2) <u>Fluorination Trays (F-2A, B or C)</u>

(a) Slowly close block valve on gas inlet line FG-4A, B or C.

(b) Close block valves on primary and secondary recycle lines, UG-5A, B or C and RG-15A, B or C.

(c) Shut down screw motor.

(d) Vibrate tray clean of powder.

(e) Shut down reactor vibrator motor.

(f) Purge tray of F_2 and UF_6.

b. <u>Switching of Spared Auxiliary Equipment</u>

(1) <u>HF Gas Blowers (H-12A or B)</u>

(a) Turn on seal feed to second blower.

(b) Open block valves in inlet line HFG-22A or B and outlet line HFG-23A or B to second blower.

(c) Start second blower.

(d) Stop first blower.

(e) Close block valves in inlet line, HFG-22A or B, and outlet line, HFG-23A or B, to first blower.

(f) Purge first blower.

(2) <u>Partial Condensers (H-7A or B)</u>

(a) Open block valve on inlet water line to idle condenser, W-12A or B.

(b) Open block valves on inlet and outlet gas lines to idle condenser, HFG-13A or B and HFL-14A or B.

(c) Close block valves on inlet and outlet gas lines to operating condenser.

(d) Close block valve in inlet water line to operating condenser.

(e) Flush the condenser removed from process stream.

(3) Primary Cooler (F-3A or B)

(a) Open block valve in inlet water line to idle cooler, W-8A or B.

(b) Open block valves in gas inlet and outlet lines to idle cooler, UG-7A or B and UG-8A or B.

(c) Close block valves in gas inlet and outlet lines to operating cooler.

(d) Purge cooler removed from process stream.

(e) Close block valve in inlet water line, W-8A or B, to cooler removed from process stream.

(4) Primary and Secondary Blowers (F-4A or B, F-8A or B)

(a) Turn on air to seals on idle blower.

(b) Open block valve in gas inlet line UG-9A or B, RG-18A or B to idle blower, and gas outlet lines UG-10A or B, or RG-19A or B.

(c) Start motor on idle blower.

(d) Stop motor on operating blower.

(e) Close block valves in gas inlet and outlet lines to operating blower.

(f) Purge blower removed from process stream.

(g) Shut off seal feed to blower removed from process stream.

(5) Cold Traps and Vaporizers

See Section V-C-3 and 4, on Cold Traps and Vaporizers for switching from one unit to another.

3. Shutdown of Gas Recycle Systems

The shutdown of the gas recycle systems is necessary when operation of the entire feed plant must be stopped.

a. HF System

(1) Close slide gates in UO_2 feed hoppers.

(2) Run under normal operating conditions until the hydrofluorination reactors are empty. Close block valves in gas inlet and outlet lines to reactors, then close block valve in HF inlet line HFG-5. Turn off powder preheaters and gas superheater and preheaters.

(3) Turn off UO_2 vibrator and screw motor.

(4) Close block valve in outlet line, HFL-16 or HFL-26, of still feed tank.

(5) Turn off column and reboiler heaters, but maintain water flow to still reflux condenser.

(6) Open valves in evacuation lines E-27A, B and C, to the HF reactors.

(7) Open bypass valve around nitrogen inlet control valve and purge system through water scrubber (H-40).

(8) Shut down HF blower, H-12A or B.

b. F_2 System

(1) Allow fluorination reactors and screws to run until low level alarms on UF_4 hopper scales are actuated.

(2) Close inlet and outlet block valves in reactor gas lines and then F_2 inlet block valve in line FG-3 from fluorine plant.

(3) Shut off primary and secondary blowers.

(4) Shut off screw and vibrator motors.

(5) Valve out all cold traps.

(6) Purge entire system through alumina trap (F-20) starting with the fluorination reactors.

(7) Turn on screw and vibrator motors and empty UF_4 hoppers and trays onto the ash receivers (bypass powder level cut-off in screw motor circuits).

c. Product Handling System

(1) Continue normal operation of cold traps until all UF_6 has been transferred to the vaporizers. Then purge traps and allow them to warm up to room temperature. Refer to Section V-A-3 for procedures.

(2) Continue normal operation of vaporizer units in order to maintain UF_6 feed to the cascade. Emergency cylinders of UF_6 must be used when normal supply from feed plant is exhausted.

E. Preventive and Remedial Operation

1. Hydrofluorination and Fluorination Systems

CONDITION	CAUSE
a. Irregular feed of UO_2.	(1) Bridging in the UO_2 feed hopper. (2) Caking in the UO_2 screw. (3) Caking in the pipe below the UO_2 screw. (4) Change in calibration of the UO_2 screw.
b. Decrease in the UF_4 hopper inventory.	(1) Caking on the hydrofluorination tray. (2) Change in vibration of the hydrofluorination tray. (3) Non-synchronized UO_2 and UF_4 feed rates. (4) Increase in powder retention time. (5) Mild caking.
c. Abnormal temperature increase in HF tray.	(1) Improper furnace control. (2) Caking.
d. Low HF consumption.	(1) Low UO_2 feed rate. (2) Incomplete conversion.
e. High HF consumption.	(1) High UO_2 feed rate. (2) Improper operation of the bleed system. (3) Improper operation of the distillation column.
f. High bleed rate.	(1) High inleakage of air or nitrogen. (2) Improper operation of the bleed system.
g. Increase in UF_4 hopper inventory.	(1) Bridging in the hopper. (2) Caking. (3) Change in UF_4 screw calibration. (4) Non-synchronized UO_2 and UF_4 feed rates. (5) Mild caking.

h. Abnormal amounts of ash.
(1) Low mass flow of fluorine gas.
(2) High UF_4 feed rate.
(3) Low reaction temperature.
(4) Caking on the fluorination tray.

i. Abnormal temperature increase in fluorination tray.
(1) Improper furnace control.
(2) Caking.

j. Low fluorine consumption.
(1) Low UF_4 feed rate.
(2) Incomplete conversion.

k. Excessive fluorine consumption.
(1) High UF_4 feed rate.
(2) High UO_2 and/or UO_2F_2 content in the UF_4 feed.
(3) High bleed rate from the fluorine system.
(4) High concentration of fluorine in the bleed gas.

l. Excessive product rate in the cleanup section.
(1) High secondary recycle flow.
(2) High UF_6 content of primary recycle stream.

m. Buildup of HF in the F_2 system.
(1) High HF concentration in the inlet fluorine.
(2) Inleakage from the hydrofluorination system.
(3) Low secondary recycle flow.
(4) Inefficient NaF trap operation.
(5) Inleakage of wet air.

a. Irregular Feed of UO_2

(1) Bridging in The UO_2 Feed Hopper

Bridging or arching of the powder in the UO_2 hopper will decrease or stop the feed of UO_2 to the reactor. Since the powder seal between the reactor and the hopper is lost when bridging occurs, HF and water vapor will condense on the powder causing it to cake. It is sometimes possible to jar the cake loose by rapping sharply on the bottom side of the hopper, but more often, it is necessary to shut down and clean out the hopper.

Although the hopper is designed with baffles to minimize bridging, plant experience may demonstrate the need for 1) installing a small bin vibrator on the side of the hopper, or 2) maintaining a lower level of powder (1,000 pounds) in the hopper.

(2) Caking in The Screw

Careful temperature control in the screw is essential. At low temperatures (below 400°F), HF is readily adsorbed by the powder causing it to become sticky; at temperatures above 800°F, the reaction between UO_2 and HF is rapid, and caking may result. Under such powder conditions, the UO_2 feed rate decreases sharply, and, in the extreme, the screw may freeze. In either case, the screw flight must be removed, cleaned, and reinstalled, the Falk torque coupling reset, and the packing gland repacked.

(3) Caking in The Pipe Below The Screw

A cake in the pipe below the screw is caused by too short a time delay between the stopping of the screw and the stopping of the reactor vibrator. The quantity of powder fed by the screw in each time cycle must move into the reactor. Should this time delay be insufficient, the powder in the pipe below the screw will pack and possibly back up causing the screw to freeze.

The caked powder may be removed by disconnecting the angled pipe from the bellows and sliding it out of the packing gland. The screw flight should then be checked for freedom of rotation and evidence of caking in the flight. If the cake extends back to the screw, or if the screw will not rotate, the flight will have to be removed as in a(2) above.

(4) Change In Calibration of The UO_2 Screw

A consistently low feed rate may be caused by a decrease in screw RPM, a small amount of cake formed on the flight, (not enough to impair materially the operation of the screw), or a decrease in density of the feed material. The decrease in feed rate may be compensated for by increasing the RPM of the screw.

b. Decrease in UF_4 Hopper Inventory

(1) Caking on Hydrofluorination Tray

At any powder flow and resulting bed depth, it is necessary to increase the reactor temperature gradually to produce a fine UF_4 powder of high assay. If either the temperature control or the powder bed depth is changed to permit excessive reaction at any point along the tray, the surface condition of the powder will be changed so that the reactivity of the powder will be lowered, and, in the extreme, caking, caused by partial sintering will occur.

Increased bed depth may be caused by either an increased UO_2 feed rate or poor tray vibration.

A rapid temperature rise at any point along the reactor indicates that a cake is being formed. Usually, it is not possible to determine immediately the direct cause of the caking. Therefore, it is necessary to check tray vibration (as described in b.(2)), screw calibration (a.(4)) and temperature indicating and controlling instruments to find the source of the trouble.

(2) Change in Vibration of The Hydrofluorination Tray

When a vibrating reactor is not supported rigidly along its entire length, the powder traveling along the reactor may tend to cover only one side of the tray, slow down, stop, or, in extreme cases, reverse direction of movement.

Under any of the above conditions of movement, the resulting powder bed will not be uniform in depth and caking can occur in the deeper portions.

Loss of rigidity in the reactors will occur for several reasons:

(a) cracks in welds between the cross-pipe supports and reactor,

(b) cracks in welds between cross-pipe supports and sliding clamps,

(c) worn rubber bushings at either the top or bottom of rocker arms,

(d) loosening of bolts or set screws which hold the rocker arms, reactor and supports together, and

(e) broken rocker arms.

The welds between the cross-pipes and reactor are normally inaccessible and should be inspected only when the furnace sections are removed. The welds between the pipes and clamps should be examined periodically and if any cracks are found, immediate repair is necessary.

Worn rubber bushings will be indicated by knocking caused by the loose fitting parts around the bushings. Loose bolts or set screws would not be noticeable immediately but, again, periodic tightening will eliminate this danger. Broken rocker arms will be obvious immediately from the resulting noise. Broken or improperly adjusted torsion bars may not affect the oscillating action of the reactors and need not be fixed immediately. However, such conditions will place unnecessary loads on the eccentric drives and should be corrected within a reasonable length of time.

Excessive warpage of a reactor will cause poor powder distribution across the tray; however, the forward movement of the powder should not change.

Change in performance of the motor, fluid drive, or variable speed drive, or excessive wear in the eccentric drive, will slow the forward speed of the powder in the reactor. If the feed rate is not decreased accordingly, the bed depth will increase and if the change in forward movement is great enough, the deeper bed will cake.

The frequency of vibration should be checked occasionally by measuring the speed of the eccentric drive with a tachometer. Although the length of stroke of the eccentric should not vary for several years, any premature wear will probably be indicated by excessive noise in the drive because of worn bearings. Proper maintenance of the motor, fluid drive, variable speed drive and eccentric drive as directed by the manufacturer will minimize the above difficulties.

(3) <u>Non-Synchronized UO_2 and UF_4 Feed Rates</u>

The RPM of both screw feeders (UO_2 and UF_4) must be so adjusted that the powder level in the intermediate hopper remains more or less constant. Therefore, a decrease in the UO_2 feed to the hydrofluorination tray (as described in section a.) or an increased UF_4 feed will lead to a decreased UF_4 inventory in the intermediate hopper. Quite often, readjustment of the speed of both screw feeders will remedy the situation.

(4) Increase in Powder Retention Time

An increase in the powder retention time in the hydrofluorination reactor may be the result of 1) a change in the frequency or amplitude of vibration of the tray, or 2) a change in the vibrational characteristics of a particular batch of powder. These conditions are not serious providing vibration is sufficient to assure continued flow of powder. The situation is first evidenced by a decrease in the UF_4 hopper inventory while the bed of powder is adjusting itself to its new retention time. Reestablishment of powder flow equilibrium will be indicated by a leveling off at a lower hopper inventory.

(5) Mild Caking

Fluctuations in hopper inventory may be caused by changes of a more temporary nature due to mild caking where the product does not adhere permanently to the reactor, but periodically breaks off and flows to the intermediate hopper.

c. Abnormal Temperature Increase in HF Tray

(1) Improper Furnace Control

The furnace temperature is kept constant by a controller acting through a relay to a contactor. If any of the three mechanisms should stick in the closed position, the furnace temperatures will rise. To remedy this occurrence temporarily, the voltage for the entire furnace should be lowered until the trouble can be found.

(2) Caking

Abnormally high temperatures in the reactor may be caused by caking as described in b.(1).

d. Low HF Consumption

(1) Low UO_2 Feed Rate

The usage of HF in the feed plant is dependent upon the UO_2 feed rate.

(2) Incomplete Conversion

The HF consumption will decrease if the conversion of UO_2 to UF_4 is incomplete for the same powder feed rate. This condition may be caused by caking as described in b.(1). Conversion also will be lowered by (a) a low HF recirculation rate (i.e., low excess HF), (b) high inert gas concentration, (c) low reactor or inlet gas temperature, and (d) buildup of the water concentration in the recycle stream. If, after observing the flow to each line, it is determined that the HF recirculation rate is low, then the suction and discharge pressures of the blowers should be noted to see if the trouble has been caused by a line plug or a defective pump. The inert gas concentration may be checked by comparing laboratory analyses of the gas stream with the concentration recorded by the HF analyzer. A low furnace temperature or a low inlet gas temperature may be caused by a burned out thermocouple, a burned out heater, or a faulty controller. Since the conversion of UO_2 to UF_4 with HF is reversible, water concentrations in the recycle stream in excess of 8 - 10% may cause incomplete conversion. This condition can be attributed directly to the operation of the partial condensers H-7A and B.

e. <u>High HF Consumption</u>

(1) <u>High UO_2 Feed Rate</u>

A high UO_2 feed rate will cause the HF consumption to increase above normal. A high UO_2 feed rate may be caused by an increase in the screw RPM or an increase in the feed material density. In either case the feed rate may be lowered by decreasing the screw speed.

(2) <u>Improper Operation of The Bleed System</u>

Faulty operation of the HF analyzer or a stuck control valve in the open position in the bleed system will increase the HF consumption. Checking of the bleed system and adjusting the HF analyzer should reveal the difficulty.

(3) <u>Improper Operation of The Distillation Column</u>

If the stripping of the HF solution being fed to the distillation column is not complete, losses to the lime pit will be excessive. If the analyses of the still waste solution show a high HF concentration, the still heater circuits, and temperature instruments, and the flow to the still should be examined to determine the source of the trouble. Leakage through the hold tank drain valve (to the azeotrope cooler) should also be checked.

f. <u>High Bleed Rate</u>

(1) <u>High Inleakage of Air or Nitrogen</u>

A high bleed rate may be caused by excessive inleakage of nitrogen or air. It is necessary to check for bad seals on the blower, a break in a bellows or a leaking nitrogen purge and vacuum relief valve.

(2) Improper Operation of The Bleed System

Faulty operation of the HF analyzer or a stuck control valve in the open position will also cause a high bleed rate, as mentioned in section e.(2).

g. Increase in UF_4 Hopper Inventory

(1) Bridging in The Hopper

Bridging problems may exist in the UF_4 hopper as already described in section a.(1).

(2) Caking

Caking in the screw flight and in the pipe below the screw is caused by either a high powder temperature, (which is unlikely since the UF_4 hopper and screw are not heated), or by a high F_2 concentration at the exit of the screw; this condition may be attributed to a change in performance of the fluorination reactor as described in section h.

(3) Change in UF_4 Screw Calibration

A change in calibration of the UF_4 screw may be caused by a slight cake on the screw flight, a change in density of the powder, or a change in the speed of the screw. (Compare to a.(4) for corrective measures.)

(4) Non-Synchronized UO_2 and UF_4 Feed Rates

Refer to section b.(3).

(5) Mild Caking

Refer to section b.(5).

h. Abnormal Amounts of Ash

(1) Low Flow of Fluorine Gas

When solid UF_4 reacts with F_2 to form UF_6 gas, any unreacted UF_4 appears as ash. At favorable temperatures and for the given reaction time, the conversion to UF_6 will be complete only when the ratio of the mass flow of F_2 to the UF_4 feed rate is sufficiently great. (Refer to Figure 1.) Thus, a low fluorine flow or a low fluorine concentration will leave an abnormal amount of unreacted UF_4.

A low gas flow may be caused by 1) a faulty flow instrument, 2) a partial plug in a line or in the "onstream" cold traps, or 3) a defective pump.

(2) High UF_4 Feed Rate

As in h.(1), if the ratio of the mass flow of fluorine to the UF_4 feed rate is low, an abnormal amount of ash will result. A high UF_4 feed rate will be indicated by a decrease in the inventory of the intermediate hopper. Poor powder distribution across the width of the tray may also result in lowered rates of conversion in that in the regions of relatively thick beds, the fluorine to UF_4 ratio is low. In the extreme, caking may result as described in section h.(4).

(3) Low Reaction Temperature

The reaction rate is lessened approximately 5% for each 25°F decrease in reaction temperature. In addition, if the temperature were to drop below 800°F, caking caused by formation of easily fusible UF_4 - UF_6 intermediates may occur (see section h.(4)).

(4) Caking On The Fluorination Tray

Caking or lumping on the fluorination tray may be caused by either 1) excessive reaction at any point along the reactor, or 2) the formation of easily fusible intermediate compounds of UF_4 and UF_6.

The former case may be due to: a) fluorine concentrations in excess of 35 mol. % in the gas stream; b) reaction temperatures in excess of 1050°F; and c) thick powder beds resulting from an increased powder feed rate or poor powder distribution along the tray. Intermediate compounds (UF_5, U_2F_9, or U_4F_{17}) may be formed at reaction temperatures below 800°F.

As in the case of the hydrofluorination tray, a rapid temperature rise at any point along the tray indicates that a cake is being formed. Usually it is not possible to determine immediately the direct cause of the caking. Therefore, it is necessary to check tray vibration (as described in section b.(2)), screw calibration (section a.(4)), functioning of the F_2 analyzer, and temperature indicating and controlling instruments to find the source of the trouble. The fluorine analyzer readings may be checked by laboratory analyses of samples drawn from SP-7. The analyzer NaBr trap charge should be changed regularly (as specified by the Instrument Department) and the instrument calibration should be checked periodically to minimize the possibilities of faulty operation. An exhausted NaBr trap will allow the concentration of fluorine to build up in the recycle system.

i. Abnormal Temperature Increase in Fluorination Reactor

(1) Improper Furnace Control

Refer to section c.(1).

(2) Caking

Refer to section h.(4).

j. Low Fluorine Consumption

(1) Low UF_4 Feed Rate

A low UF_4 feed rate is recognized by a reduction in the amount of fluorine consumed in the reaction and an increase in the UF_4 hopper inventory. The UF_4 feed rate may be affected by the items already described under section g.

(2) Incomplete Conversion

Caking or lumping of the UF_4 or poor powder distribution across the reaction tray will lower the conversion efficiency as discussed in section h. This condition may often be recognized by an increased concentration of fluorine in the bleed gas from the secondary recycle stream.

k. Excessive Fluorine Consumption

(1) High UF_4 Feed Rate

Excessive fluorine consumption, caused by an increased UF_4 feed rate, is usually accompanied by an increased amount of ash since the efficiency of conversion as described in section h.(1) is lowered. This condition is easily corrected (see section b.(3)).

(2) High UO_2 and/or UO_2F_2 Content in The UF_4 Feed

An occasional poor batch of UF_4 will, most often, be the cause of increased fluorine consumption (UO_2 and UO_2F_2 require more fluorine than does UF_4). This condition may be traced, in almost all cases, to the particle size distribution and the state of oxidation (U_3O_8 content) of the UO_2 feed.

(3) High Bleed Rate From The Fluorine System

Since the fluorine system is pressure controlled, an increase in the amount of inert gases admitted will raise the bleed rate and thus, increase the amount of fluorine leaving the system. Increased inert gas buildup may be caused by: 1) O_2 formed from the reaction of UO_2 or UO_2F_2 with F_2 (as described in section k.(2)); 2) inleakage of N_2 or air from a defective blower seal, a broken inner bellows or a leaking purge valve. In addition, a malfunctioning bleed control valve would permit excessive bleed.

(4) High Concentration of Fluorine in The Bleed Gas

An augmented amount of HF admitted to the fluorine system (either from the fluorine plant or the hydrofluorination step) will necessitate increasing the secondary recycle flow in order to keep the HF concentration of the fluorination system low enough to prevent its condensation in the cold traps. The increased flow may cause a less efficient cleanup of the fluorine resulting in a greater loss of this gas.

A high concentration of fluorine in bleed gas accompanied by a corresponding increase in ash is referred to in section j.(2).

l. Excessive Product Rate in The Cleanup Section

(1) High Secondary Recycle Flow

A high gas flow and/or a high fluorine concentration (see section h.(4)) entering the cleanup section will increase the UF_6 production in the cleanup section at the expense of low fluorine percentage utilization.

(2) High UF_6 Content of Primary Recycle Stream

Excessive UF_6 in the primary recycle stream resulting from poor operation of the primary cold traps will increase the UF_6 product rate in the cleanup section. (See Section V-E-2).

m. Buildup of HF in The F_2 System

This condition may be verified by gas samples taken at sample points SP-6 and SP-9.

(1) High HF Concentration in Inlet Fluorine

A high HF concentration in the fluorine system may be caused by high HF concentration in the inlet fluorine. This may be checked by analysis of the inlet gas and corrected by the fluorine plant.

(2) Inleakage From Hydrofluorination System

The hydrofluorination system is a second source of HF inleakage. HF may be admitted to the fluorination reactor through a bad powder seal (i.e., too low an inventory in the UF_4 hopper) or it may be carried in with the UF_4 feed. In the second case adding heat to or insulating the UF_4 hopper may be necessary.

(3) Low Secondary Recycle Flow

The main function of the secondary recycle is to maintain the HF concentration of the fluorine system at a sufficiently low level to prevent its condensation in the cold traps. Thus, buildup of HF in the fluorine system may be caused by inadequate flow to the secondary recycle NaF traps.

(4) Inefficient NaF Trap Operation

Inefficient removal of HF in the NaF traps may be caused by: 1) an exhausted trap, or 2) a trap operating at too high a temperature, or 3) the quality of the NaF pellets.

The efficiency of the NaF pellets to adsorb HF will decrease as the number of adsorption and regeneration cycles increases. The usage of NaF should be small and approximately the same as that found in the operation of the fluorine plant traps.

(5) Inleakage of Wet Air

A high HF concentration may be due to inleakage of wet air in that F_2 and UF_6 will react with water vapor to form HF gas.

2. Product Handling System

Condition	Cause
Cold Trap Condensing Cycle	
a. High outlet gas temperature.	(1) Uneven flow distribution between onstream cold traps. (2) Insufficient cooling of traps. (3) High inlet gas temperature.
b. Premature decrease in flow through trap.	(1) Bridging of UF_6 in cold trap. (2) Plugging in annulus or outlet pipe inner shell. (3) Plugging in inlet pipe.
c. Pressure surges in trap.	(1) Leakage of refrigerant (CO_2) from inner shell.
Heating and Draining Cycle	
d. Slow temperature rise.	(1) Burned out heaters. (2) Refrigerant supply valve open or leaking.
e. Abnormal pressure.	(1) Overheating. (2) Presence of HF. (3) Incomplete evacuation of inert gases. (4) Leakage through process valves. (5) Leakage through relief valve and rupture disc.
f. Leakage of UF_6 to atmosphere.	(1) Break in head or shell of cold trap. (2) Broken bellows in valve.
g. Draining of UF_6 retarded or stopped prematurely.	(1) Contents incompletely heated. (2) Cold spots on drain line. (3) Vapor lock in drain line or in vaporizer. (4) Pressure in vaporizer higher than in cold trap. (5) Drain line plugged because of accumulation of solid particles.
Cooling Cycle	
h. Slow cooling rate.	(1) Refrigeration system overloaded. (2) Needle valve plugged.

Vaporizers

i. Excessive pressure over a prolonged period.	(1) Heating or air circulation rate too high.
j. Low pressure of UF_6.	(1) Heating or air circulation rate too low. (2) UF_6 level too low.

Condensing Cycle

a. High Outlet Gas Temperature

(1) Uneven Flow Distribution Between Onstream Cold Traps

Uneven flow between cold traps in the primary recycle stream (only one trap at a time is used in the secondary) may cause a high outlet gas temperature from the trap having the higher flow. If after checking the flow indicators to the cold traps, it is established that the cause of the high outlet gas temperature is due to uneven flow distribution, the trap having the smaller flow should be taken offstream, since it is beginning to plug, and a standby trap valved in.

(2) Insufficient Cooling of Traps

Insufficient cooling of the cold trap before it is turned "onstream" may cause a high outlet gas temperature, hence a high UF_6 concentration leaving the trap. If the outlet gas temperature is higher than plus 20°F on the primary or minus 10°F on the secondary, the trap should be removed from the stream and cooled further.

(3) High Inlet Gas Temperature

A high inlet gas temperature may result if the gas coolers (F-3A or B, F-7A, B or C) are not performing properly. Therefore, the water temperature to and from the coolers and the inlet process gas temperature should be checked if a high outlet gas temperature is observed.

b. Premature Decrease in Flow Through Trap

(1) Bridging of UF_6 in Cold Trap

Bridging of UF_6 in the first pass of the cold trap may occur because of an unusually large accumulation of solid UF_6 at one of the baffles. A slight pressure increase may be effective in relieving the bridging. This may be accomplished by closing the valve momentarily on the outlet of the other onstream trap.

(2) Plugging in Annulus or Inner Shell Outlet Pipe

Plugging in the annulus or in the outlet pipe of the inner shell may result if the concentration of UF_6 in the gas entering the trap becomes too high. This condition may be caused by a high UF_4 feed, improper cold trap operation, or by any of the items stated in Section V-E-2-a above. If the concentration is too high, the UF_6 will not be stripped completely in the first pass and will deposit in the narrower passages of the second (annulus) and third (outlet pipe) passes. Plugging in the inner shell may also be caused by distillation of UF_6 into this shell during the heating or cooling cycle. Solid UF_6 will accumulate in the passages and result in a plug immediately after the trap is turned onstream.

If the trap is plugged because of either of the reasons stated, it is necessary to remove the trap from the stream and reheat the contents. Care must be taken to see that the inner shell is heated to a higher temperature than the outer shell to prevent recurrence of this condition.

(3) Plugging in Inlet Pipe

Plugging in the inlet pipe will occur if the cold trap inlet head calrod tracing is not heating properly.

c. Pressure Surges in The Trap

An abnormal pressure fluctuation in the cold trap may indicate a leakage of CO_2 from the inner shell. If a leakage occurs, it indicates the inner shell may soon fail; therefore, the trap must be isolated and the refrigerant drained from the inner and outer shell tubes. Before draining the refrigerant, the suspected leak should be verified by evacuating the trap and noting if the pressure rises in the trap when the evacuation line is closed.

Heating and Draining Cycle

d. Slow Temperature Rise (Less than $2^{\circ}F$ Per Minute)

(1) Burned Out Heaters

There may be as much as a half-hour lag before the temperature starts to rise after the inner shell heater is turned on since the liquid CO_2 must be exhausted from the shell. Should the temperature fail to rise at any point after this period, all calrod heaters should be checked to make sure they are still functioning. If a heater is burned out, the cold trap must be removed from service until the heater is repaired or replaced. Lights on the panel board indicate when current is flowing to the inner or outer shell heaters (no lights are provided for either the inlet or outlet head calrod tracings or for the insertion heaters).

(2) Refrigerant Supply Valve Open or Leaking

A leaking or partially open refrigerant valve will retard the heating rate. If a refrigerant valve is stuck open, the trap must be removed from service, the refrigerant supply shut off and the refrigerant drained to permit the valve to be repaired.

e. Abnormal Pressure

(1) Overheating

If the heating rate is too rapid, or if the heater cut-off on the temperature recorders or the pressure switch fail to function, the contents of the trap may become overheated and cause high pressures. To avoid relieving the trap contents to the surge drum (F-39) through the relief valve and rupture disc, (at 50 psig) the heaters must be shut off manually whenever the pressure rises above the control point (35 psig).

(2) Presence of HF

HF condensed with the UF_6 will cause a pressure higher than the UF_6 vapor pressure should be for corresponding cold trap temperatures. If this condition is indicated, the outlet process gas line valve from the cold trap should be cracked until normal pressures are restored.

(3) Incomplete Evacuation of Inert Gases

If the inert gases are not bled from the cold trap before the heating cycle is started, the pressure in the trap will be higher than the normal UF_6 vapor pressure. This condition should be relieved during the early part of the heating cycle by cracking the outlet gas valve. This valve should not be opened if the temperature in the trap is over $100^{o}F$ since there would be danger of introducing large amounts of UF_6 to the process stream. In the event that the trap is above $100^{o}F$ before the presence of inert gases is discovered, these gases should be removed only after the UF_6 in the trap has been liquefied and drained to the vaporizers. Unless the trap overheats, the maximum pressure developed in the trap will not exceed 35 psig with inert gases present and UF_6 in the liquid state. After the contents of the trap have been drained to the vaporizer, the inert gases remaining in the cold trap, vaporizer, and vaporizer manifold should be admitted slowly to the cold trap inlet header UG-10 by opening the valve in line UG-35A, B, or C, the gas return line from the vaporizer.

(4) Leakage Through Process Valves

Leakage through one of the process valves will cause escape of UF_6 to the system during heating and will be indicated by a low trap pressure. If the valve is stuck while the UF_6 pressure and temperature are still below the triple point ($147^{o}F$), the contents of the trap should be distilled slowly into other onstream traps by way of the cold trap inlet header. If the contents are liquid, the trap must be drained immediately to the vaporizer. Caution: Do not ever open the valve to the cold trap inlet header if the contents of the trap are completely liquefied, since liquid UF_6 might syphon to the header.

(5) Leakage Through Relief Valve and Rupture Disc

A leak in the relief valve and rupture disc will permit the UF_6 to escape to the surge drum. The pressure between the relief valve and rupture disc should, therefore, be checked periodically.

f. Leakage of UF_6 to Atmosphere

(1) Break in Head or Shell of Cold Trap

A break in the head or shell of the cold trap may occur because of (a) stresses caused by rapid cooling or heating, (b) a short circuited calrod heater. If a leakage of UF_6 to the atmosphere is noted during the heating cycle, the contents should be distilled to the onstream cold traps by way of the inlet header.

(2) Broken Bellows in Valve

Another source of leakage is a broken bellows in one of the process valves. Again the contents of the trap should be distilled to the onstream cold traps. In order to repair or replace one of these valves, it will be necessary to shut down the entire feed plant.

g. Draining of UF_6 Retarded or Stopped Prematurely

(1) Contents Incompletely Heated

If the UF_6 in the cold trap is not completely liquefied due to incomplete heating, solid particles of UF_6 may plug spaces between baffles and prevent complete draining. Temperatures at all points in the trap should be checked. If any temperature is low, the drain line should be closed and the heating continued.

(2) Cold Spots in Drain Line

Any cold spots (below $160^{\circ}F$) in the trap or in the drain line will cause UF_6 to solidify and prevent draining. Again all temperature points should be checked, and the contents heated further if a low temperature point is observed.

(3) Vapor Lock in Drain Line or in Vaporizer

If none of the temperatures are low, a vapor lock may be suspected as being the cause of incomplete drainage. To break this lock, the valve in line UG-35A, B or C should be cracked to bleed gases from the vaporizer to the primary cold trap inlet header UG-10. This valve should be closed as soon as the liquid flow resumes.

(4) Pressure Higher in Vaporizer Than in Cold Trap

Before any steps are taken to restore liquid UF_6 flow, the pressure in the vaporizer should be checked to see that it is lower than the pressure in the cold trap. If it is not, either the vaporizer must be cooled or the cold trap heated further. A differential of at least 5 psi is desired between vaporizer and cold trap pressures.

(5) Drain Line Plugged Because of Accumulation of Solids

The cold trap drain line may become plugged through the accumulation of non-volatile solid particles in the trap. If this should occur, the contents must be distilled into another cold trap, and the cold trap removed from service until the drain line is unplugged.

Cooling Cycle

h. Slow Cooling Rate

(1) Refrigeration System Overloaded

If more than four traps are cooling at one time, the refrigeration system may be overloaded. It is desirable to stagger cold trap cooling cycles so that no more than two traps are cooled at one time.

(2) Needle Valve Plugged

Accumulation of oil in the needle valve in the refrigeration line may cause it to plug and prevent flow of refrigerant to the trap. If this condition results, a decrease in cold trap temperature will be observed if the bypass valve around the needle valve is opened momentarily to allow increased refrigerant flow. By closing the bypass valve and "working" the needle valve, it may be possible to relieve the plug.

Vaporizer Operation

i. Excessive Pressure Over a Prolonged Period

Overheating because of high variac settings or high air circulation rate can cause a high vaporization rate and excessive pressures in the vaporizers. The variac settings should, therefore, be observed at frequent intervals and adjusted if the pressure appears to be building up.

j. Low Pressure of UF_6

(1) Heating or Air Circulation Rate Too Low

The wall temperature of the vaporizer should be checked if the pressure is too low. Heater variacs should be adjusted and the hot air circulation checked if the wall temperature is below the desired vaporization temperature.

(2) UF_6 Level Too Low

A low level of UF_6 may present a low heat transfer surface to the air circulating around the cylinder thus the vaporization rate would be below the necessary cascade feed rate. When this condition occurs, a full vaporizer must be valved into the cascade feed supply header.

VI. PURGE OF FEED PLANT EQUIPMENT

There are two systems for purging toxic gases and liquids from the equipment and piping in the feed plant, one for the hydrofluorination equipment, and the other, for the fluorination equipment.

Equipment that normally contains water-HF solutions is provided with water flush connections. The operating procedure for flushing each item of equipment appears below.

All equipment that normally contains gaseous HF and F_2 is purged with nitrogen. Separate nitrogen lines connect to each item of equipment. A common header (E-2) carries the purge gases from the HF equipment to the water scrubber (H-40). The acid solution from the scrubber is passed through a pile of crushed limestone and thus neutralized. Three evacuation headers, E-1, E-31 and E-39 carry the purge gases from the F_2 equipment through an alumina trap, F-20, and vacuum pump, F-21, to the vent stack.

The purge procedure for each item of equipment follows.

A. HF Purge System

1. Water Flushing System

a. Distillation Column (H-10)

(1) Rack out all heaters and allow column to cool.

(2) Close block valves in

(a) column feed inlet line HFL-16,

(b) reflux condenser outlet line HFG-19 (this valve is normally locked open).

(3) Open block valves in

(a) column drain line HFL-27,

(b) liquid leg bypass line.

(4) Open block valve in water flush line connection to line HFG-17.

(5) Flush until a sample taken at SP-2 (located near the azeotrope cooler) has the same pH value as the inlet water.

(6) Turn water off and allow column to drain.

b. Azeotrope Cooler (H-14)

The cooler may be flushed either in conjunction with the still column or separately as desired.

To flush separately from column:

(1) Close valves in

(a) column waste line HFL-25 (this valve is normally locked open),

(b) hold tank drain line HFL-26,

(c) bypass from HFL-26 to HFL-16.

(2) Connect water hose to flush connection in line HFL-26.

(3) Open valves in

(a) HFL-26 below flush connection,

(b) liquid leg bypass line HFL-27,

(c) flush connection.

(4) Flush as in a.(5).

(5) Turn off water and allow cooler to drain.

c. Reflux Condenser (H-11)

(1) Follow procedure for flushing distillation column, except use flush line connection to line HFG-17 near gas inlet to condenser instead of connection near still.

d. Partial Condenser (H-7A or B)

(1) Close valves in

(a) condenser outlet HFL-14A or B,

(b) condenser inlet HFG-13A or B.

(2) Open valve in condenser drain line leading to line HFL-26.

(3) Connect water hose to condenser flush connection.

(4) Alternately fill and drain condenser at least four times to remove all HF.

e. Hold Tank (H-9)

(1) Close valves in

(a) still feed line HFL-16,

(b) condenser inlet lines HFL-13A and B,

(c) pump inlet lines HFG-22A and B,

(d) reflux condenser gas outlet line HFG-19.

(2) Open valves in

(a) drain line HFL-26,

(b) flush connection to partial condenser H-7A or B,

(c) liquid leg bypass in line HFL-27.

(3) Connect water hose and turn on water.

(4) Flush as in a.(5).

(5) Turn off water and allow hold tank to drain.

(6) If line HFL-26 is plugged at hold tank, close valve downstream of the flush connection in line HFL-26 and connect water hose.

(7) Run water back through line HFL-26 into hold tank to loosen plug.

(8) Allow tank to drain and then flush as above.

(9) Extreme caution must be used in flushing hold tank to prevent backup of water into HFG-32 leading to pumps. If water should get to pumps, it must be removed by heating pumps and purging with nitrogen.

2. Nitrogen Purge System

Before purging any equipment open the water inlet block valve to the scrubber (H-40) in line W-24.

a. HF Blowers (H-12A or B)

(1) Close valves in

(a) blower inlet line HFG-22A or B,

(b) blower outlet line HFG-23A or B.

(2) Open valves in

(a) purge outlet line E-5A or B,

(b) nitrogen inlet line N-30A or B.

(3) Purge for fifteen minutes.

b. NaF Traps (H-13A or B)

(1) Close valves in

(a) trap inlet line HFG-11A or B,

(b) outlet line HFG-30A or B.

(2) Open valves in

(a) outlet to vent line HFG-30A or B,

(b) N_2 inlet line N-19A or B.

(3) Raise trap temperature to 600°F.

(4) Purge until sample shows no HF.

c. Superheater (H-3)

(1) Rack out heaters.

(2) Open valve in bypass line.

(3) Close inlet and outlet valves in line HFG-6.

(4) Open valve in line E-7.

(5) Open valve in line N-5 and purge for fifteen minutes.

d. Mixing Chamber (H-4)

(1) Close valves in

(a) HF recycle line HFG-24,

(b) NaF trap control valve inlet line HFG-28 and bypass line,

(c) blower discharge lines HFG-23A and B,

(d) NaF trap process return lines HFG-30A and B,

(e) HF inlet line HFG-5 and control valve (CV-754) bypass line,

(f) superheater inlet line HFG-6 and bypass line.

(2) Open purge valve in line E-6.

(3) Open N_2 inlet valve in line N-29 and purge for fifteen minutes.

(4) Open valve to vent line HFG-28A for last five minutes of purge.

e. HF Reactors H-6A, B or C and HF Preheaters H-5A, B or C

(1) Close valves in

(a) reactor inlet line HFG-9A, B or C,

(b) reactor outlet line HFG-10A, B or C.

(2) Open valve in purge line E-27A, B or C.

(3) Open valve in N_2 line N-14A, B or C.

(4) Purge until sample taken at SP-4A, B or C shows no HF.

B. Fluorination Purge System

1. Reactors (F-2A, B or C), Dust Separators (F-38A, B or C), Secondary Coolers (F-7A, B or C), and Dust Filters (F-6A, B or C)

a. Close valves in

(1) fluorine inlet line FG-4A, B or C,

(2) secondary recycle line RG-15A, B or C,

(3) primary recycle line UG-5A, B or C,

(4) Gemco valves immediately before the ash receivers.

b. Open N_2 valve in line N-22A, B or C.

c. Open evacuation valve in line E-20A, B or C.

d. Allow to purge for five minutes, then throttle N_2 valve until reactor pressure drops to 3" vacuum.

e. Take a sample every fifteen minutes at sample point SP-6A, B or C and check for UF_6.

f. Purge until UF_6 is completely removed.

2. Ash Receivers (F-13A, B or C)

a. Close Gemco valves.

b. Alternately pressure with N_2 by opening valve in line N-20A, B or C, and evacuate by closing N_2 valve and opening evacuation valve in line E-32A, B or C.

3. <u>F_2 Mixing Chamber (F-1)</u>

   a. Close valves in

      (1) secondary recycle return line RG-27 and control valve (CV-939) bypass,

      (2) F_2 inlet line FG-1 and control valve (CV-955) bypass,

      (3) primary recycle lines RG-12A through F at the outlet of all F-5 cold traps,

      (4) inlet lines FG-4A, B or C to reactors F-2A, B or C.

   b. Alternately open and close N_2 inlet valve in line N-8 and evacuation valve in line E-11 to purge and evacuate mixing chamber.

   c. Continue this procedure until sample taken at sample point SP-13 shows no F_2.

4. <u>Primary and Secondary Blowers (F-4A or B and F-8A or B)</u>

   a. Close valves in

      (1) blower inlet line UG-9A or B, RG-18A or B,

      (2) blower outlet line UG-10A or B, RG-19A or B.

   b. Open N_2 inlet valves in lines N-10A or B, N-7A or B.

   c. Open evacuation valves in lines E-15A or B, E-10A or B.

   d. Throttle vacuum pump discharge to give 20" vacuum as shown on PI-1066 and purge for fifteen minutes.

   e. Blowers must be manually rotated backwards a few revolutions during purging.

5. <u>Primary Gas Cooler (F-3A or B)</u>

   a. Close valves in

      (1) cooler gas inlet line F-7A or B,

      (2) cooler gas outlet line F-8A or B.

b. Open evacuation valve in line E-12 or 13 until cooler is evacuated.

c. Alternately open and close N_2 inlet valve in line N-6 or 9, and evacuation valve in line E-12 or 13 until cooler is clear of toxic gases.

6. Cold Traps (F-5A-F, and F-9A, B or C)

a. Close valves in

(1) cold trap outlet line RG-12A-F, or RG-22A, B or C, and 1/4" bypass line,

(2) cold trap inlet line UG-11A-F or RG-21A, B or C,

(3) liquid drain line UL-30A-F or UL-41A, B or C,

(4) evacuation header E-24 to header E-1 to prevent possible pressure buildup in reactors.

b. Heat trap being purged to room temperature.

c. Pump trap down through line E-39 by opening valves in lines E-19A-F or E-17A, B or C.

d. Close valves in E-19A-F or E-17A, B or C and bleed air through valves in line A-5A-I until trap reaches atmospheric pressure. Caution must be used in pressuring traps as the air line A-4 is at 40 psig.

e. Repeat steps c and d until trap is clear of toxic gases as shown by samples taken at SP-12 in line E-24.

7. NaF Traps (F-10A or B)

a. Close valves in

(1) inlet line RG-24A or B,

(2) outlet to process line RG-25A or B.

b. Open outlet valve in RG-26A or B to vent line RG-28.

c. Heat trap to 600°F.

d. Open N_2 inlet line N-12A or B.

e. Purge trap until the HF is removed.

VII. HEALTH AND SAFETY

Because of the presence of uranium and the toxic gases, HF, fluorine, and UF_6 in the feed plant, it is necessary for personnel either working or visiting in the area to observe strict safety rules. Special protective equipment will be provided for all persons concerned and instructions given in its proper use.

The potential plant hazards, the protection from these hazards and the detection instruments used to locate them are as follows:

A. Exposure to Uranium in The Form of UO_2, UF_4, UF_6 and Ash From The Reactors

Exposure to uranium can come from (1) handling of the UO_2 feed for the plant, (2) breaks in the system during operation, (3) cleaning out equipment which has been opened for maintenance, or (4) handling of the ash receivers.

Personnel working in the area should be provided with safety glasses, coveralls, gloves, shoe covers or issued shoes, and head covers to be worn at all times. This equipment is to be put on in the "hot" locker room and, once worn in contaminated areas, is not to be worn in designated "cold" areas. Visitors in the operating area should be provided with shoe covers and safety glasses.

In addition to the above items, all personnel should be provided with respirators (Comfo, all dusts, BM-2133 filters) to be worn when performing operations where air contamination is expected, i.e., loading hoppers, changing bellows, cleaning out equipment, etc.

Welders should wear the special Welders Gas Mask (for gases or dusts) when working on feed plant equipment in place.

No smoking or eating should be allowed in the feed plant "hot" areas. Operating and maintenance personnel should be required to remove contaminated clothing in the "hot" locker room and take a shower before leaving the plant at the end of a shift.

Signs should be provided to direct people entering the building to use only those entrances leading to the "cold" area. It should not be permissible to enter the "hot" areas without, first, going through the cold locker room or other designated entry points where suitable protective clothing can be obtained.

The following detection equipment should be supplied for measuring personal or area contamination: (a) Film badges should be worn by operating and maintenance personnel and turned in to the Health Physics Group every week to be checked for exposure; (b) Continuous air samplers should be placed at several points in the building to check on air-borne contamination (Cynco Pressovac Pump with Special

Filter paper holder - Tolerance air count is 2 counts/ft^3/min.); (c) Portable alpha and beta-gamma detection instruments should be used to check all items of equipment removed from the system before maintenance work is performed on these items. Over-tolerance contamination from exposed surfaces must be reduced to a safe level before removal of such equipment from the operating area. Surface contamination of the floor, walls, and equipment should be checked periodically with the portable instruments, and all such contamination immediately reduced to below tolerance level; (d) An alpha hand counter should be located in the locker room area so that all personnel leaving the operating area (e.g., at lunch time, the end of a shift, etc.) can check their hands for contamination. Contamination can be removed by one or several washings with soap and water.

B. <u>Exposure to Toxic Gases, HF, Fluorine and UF_6</u>

Exposure to these gases may occur when a leak develops in piping, the equipment, valves, bellows, etc., or when equipment is opened after insufficient purging.

Army Assault masks should be placed in several convenient places throughout the plant. In the event of a break in the system during operation, these masks should be worn by all persons in the immediate area until the area has been cleared of the contamination.

Safety showers are also provided for use in emergencies. These showers are located as follows:

1. Ground floor near HF still.
2. Ground floor at each end of the Cold Trap area.
3. Mezzanine floor near the HF pumps.
4. Mezzanine floor near the feed plant fluorine compressors.

C. <u>Protection From Radiation</u>

The ash receivers are the only items of plant equipment which need shielding to protect the operating personnel against radiation. A one inch thick steel cover placed over each receiver is sufficient to reduce the gamma intensities of the ash to tolerance level*. This shield remains on the receiver during transportation to the point of storage, where it is to be removed, with a minimum exposure of any operator in the storage area. The shield is then returned to the feed plant to be reused to shield other ash receivers.

D. <u>Safety In General</u>

In addition to the possible exposure to Uranium and toxic gases in the feed plant, the working personnel will be subject to other potential hazards,such as:

*Memo KS-120, H. F. Henry to R. B. Korsmeyer, April 11, 1950.

1. Some equipment will be operating at extreme temperatures (1000° - 1200°F; minus 55°F). This equipment will be insulated or covered for adequate protection during normal operation, but may present a hazard from contact during maintenance.

2. Because of misoperation or faulty control equipment, it might be possible to build up excessive pressure in some vessels in the feed plant. Wherever necessary, such equipment is protected against high pressures by relief valves. These relief valves are in series with block valves so that they may be removed for maintenance. During normal operation, the block valves are locked open. A periodic check should be made on all relief valves to make certain they are in operating condition.

3. Certain operations will require the use of platforms and catwalks well above floor level. Hand rails and protected ladders and stairways have been provided wherever necessary.

VIII. ACKNOWLEDGEMENT

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D. C. Brater
D. C. Brater

B. A. Kress
B. A. Kress

C. C. Littlefield
C. C. Littlefield

R C Olson
R. C. Olson

S H Smiley
S. H. Smiley

Approved: R B Korsmeyer
R. B. Korsmeyer
Design and Development Department

lee:ikg

IX. APPENDIX

A. References

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B. Sample Points

LOCATION AND SERVICE

Sample Point Number	Location	Type Sample	Analyze For	Service
SP-1	Outlet NaF Trap H-13A - Mezzanine	Gas	HF	Trap efficiency
SP-2	Azeotrope Disposal Line - Main Floor	Liquid	Acidity	Still efficiency
SP-3	Outlet NaF Trap H-13B - Mezzanine	Gas	HF	Trap efficiency
SP-4 A to C	Outlet Reactors H-6A-C - Main Floor	Gas	HF	UO_2 Conversion
SP-5	Outlet Mixing Chamber H-4 - Mezzanine	Gas	HF	Concentration
SP-6 A to C	Outlet Dust Filters F-6A-C - Main Floor	Gas	F_2	F_2 Cleanup efficiency
SP-7	Inlet Blowers F-4A and B - Mezzanine	Gas	F_2	Concentration
SP-8 A to C	Primary Outlet Reactors - F-2A-C Main Floor	Gas	F_2	UF_4 Conversion
SP-9	Outlet Mixing Chamber F-1 - Mezzanine	Gas	F_2	Concentration
SP-10 A to D	Vaporizer Inlet Manifold - F-19A-D Main Floor	Liquid	UF_6	Purity
SP-11	Vent Line to Stack - Mezzanine	Gas	HF, F_2, UF_6	Atmosphere contamination
SP-12	Evacuation Line, E-24 from Cold Traps - Main Floor	Gas	F_2, UF_6	Concentration
SP-13	Primary Recycle Inlet to Mixing Drum F-1	Gas	F_2	Concentration
SP-14	Surge Drum Inlet - F-39	Gas	UF_6	Inventory
SP-15	Outlet NaF Traps F-10A & B - Mezzanine	Gas	F_2	Concentration

Sample Points - Location And Service (Figures 2 and 3)

Sample connections are located at various points in the process piping so that periodic control checks can be made. The gas sample connections consist of two valves in a 1/2" pipe with a 1/2" male flare connector on the end for connecting the sampling equipment. A special sampling unit is built in for sampling the liquid product flowing to the vaporizers. The location and use of the sample taps are given below.

SP-1 Located in the gas outlet line from NaF trap H-13A on the mezzanine. Gas samples taken at this point and analyzed for HF serve to check the efficiency of the adsorption as well as to determine when the trap should be regenerated.

SP-2 Located in the azeotrope disposal line (HFL-27) from the still on the ground floor. Liquid samples taken at this point and analyzed for acidity serve to check the efficiency of the still operation. It may also be employed during flushing operations to check the acidity of the flush water.

SP-3 Located in the gas outlet line from NaF trap H-13B on the mezzanine. Serves same purpose as SP-1.

SP-4 A to C Located in the outlet gas line from reactors H-6A to C on the ground floor. Gas samples taken at this point and analyzed for HF may be compared to samples from SP-5 as a check on the conversion of UO_2 to UF_4 in the reactor. SP-4 is also used to determine the completeness of purging the reactor.

SP-5 Located in the outlet line from the gas mixing chamber H-4 on the mezzanine. Gas samples taken at this point and analyzed for HF give the concentration of the inlet gas to the reactors. The gas analyzer is also connected to this point.

SP-6 A to C Located in the secondary gas recycle line in the outlet from the dust filters F-6A to C on the ground floor. Gas samples taken at this point and analyzed for fluorine serve to check the efficiency of the operation of the cleanup section of the reactor. SP-6 is also used to determine the completeness of purging in the reactor.

SP-7 Located in the inlet line to the primary gas blowers, F-4A and B, on the mezzanine. It is used in conjunction with SP-9.

SP-8 A to C Located in the primary recycle gas outlet line from reactors F-2A-C on the ground floor. Gas samples taken at this point and analyzed for fluorine serve to check the efficiency of the reactor operation.

SP-9 Located in the outlet line from the gas mixing chamber, F-1. This is a special connection for a 1/2" copper line that connects to the suction side of the primary blowers, F-4A and B at SP-7. The contlnouus gas analyzer (XX-953) gets its sample from this 1/2" line. A detailed procedure for the operation and maintenance of the continuous analyzer will be issued by the Instrument Department.

SP-10 A to D Located in the inlet manifold to the vaporizers. Liquid samples taken at this point and analyzed for UF_6 serve to check the purity of the product.

SP-11 Located in the vent line to the stack on the mezzanine. Samples taken at this point and analyzed for HF, F_2 and UF_6 serve to show how much toxic gas is being discharged to the atmosphere.

SP-12 Located in the inlet line to the alumina trap, F-20. Samples taken at this point are used to determine when purge gases are free of UF_6 and F_2.

SP-13 Located on the outlet line of the primary cold traps. Samples taken at this point check the efficiency of the cold trap.

SP-14 Located in the inlet line to surge drum F-39. These samples, taken only if a cold trap has "blown" its contents into F-39, serve to show - (1) the composition of the material in the surge drum, and (2) how completely the surge drum has been emptied and purged back to the feed plant cold traps.

SP-15 Located in the outlet line of the NaF traps F-10A and B. This sample line is connected to the continuous gas analyzer (XX-949) which records the fluorine concentration in the bleed gas.

C. Equipment Specifications and Service

H-3	HF Superheater	One Required
JS-262-1	Drawing No. F-917-2 Rev. A	
	Industrial Process Engineers	

All metal in contact with gas is Inconel. A 6" diameter header contains the tube sheets into which are welded three, one-pass 1-1/2" schedule 40 Inconel pipes. Two, 2-1/2" lengths of 8" pipe at each end of unit support the insulation. Overall length, is 6' 7-1/4". The overall diameter is 14-1/8". Unit is mounted in a vertical position. Heated by six #TI 6015XX Chromalox heaters 2500 watts @ 230 V., two heaters are clamped on each 1-1/2" Inconel pipe. Heated length is 55". Electrical elements are accessible for replacement without opening process side of equipment and without damage to insulation. Insulation is removable and consists of 2-1/2" thick Unibestos. Maximum operating temperature 1200°F; operating pressures are 5 psi internal, 15 psi external. Unit constructed in accordance with A.S.M.E. code P U-68; stress relieved; corrosion allowance 0.125".

H-4	Gas Mixing Chamber	One Required
JS-262-2	Drawing No. D-896-7 Rev. C	
	Industrial Process Engineers	

Cylindrical vessel, dished ends, 3' 3-1/2" long, 18" outside diameter, 5.3 ft^3 capacity. All parts in direct contact with vessel contents are Monel. Internal pressure 5 psi; external pressure 15 psi; operating temperature 200°F. Constructed according to A.S.M.E. code P U-68; stress relieved; corrosion allowance 0.125". Vessel is mounted vertically with two gas inlets located on the top sides, one 3" and the other 1". A 3" outlet is located on the bottom. Vessel is equipped with two 4" inspection flanges located on the side 180° apart, one near the top, the other near the bottom. Vessel is supported by three steel legs spaced 120° apart. No heat required. One inch 85% magnesia insulation.

H-5 | HF Preheater | Three Required

JS-262-3 | Drawing No. F-917-1 Rev. A

Industrial Process Engineers

Unit is rectangular in shape, 6' 9-1/2" overall length x 23" x 23-1/2" (Including insulation). All metal in contact with gas is Inconel. Unit has six, two-pass (U-bend at one end) one inch schedule #40 seamless pipes welded into the tube sheet in two planes parallel to each other, separated by an Inconel septum to provide inlet and outlet sides. Insulation is removable and consists of 1-1/2" Superex backed by 3-1/2" 85% magnesia. Heated by twelve #TI-6015 XX, 1200 watts, 230 V., Chromalox heaters clamped on tubes. Electrical elements are accessible for replacement without opening process side of unit and without damage to insulation. Heated length of unit is 4' 6". Internal working pressure - 5 psi; external working pressure - 15 psi; maximum operating temperature - 1200°F; corrosion allowance - 0.125". Unit designed and constructed in accordance with A.S.M.E. code P U-68; stress relieved.

H-6 | HF Reactors | Three Required

Drawing No. AK-1389

Link-Belt Company

A 41' 8" long x 24" x 4" high, 1/2" thick conveyor is attached to the drive mechanism by ten 4" standard schedule 80 Inconel pipes welded to side and bottom of Inconel trough. Nine sets of four leg forward reactors; two sets of four leg return reactors; drive is a H-4 P.I.V., E.D.-254 electro-fluid drive, fitted with a 5 H.P., 1750 RPM, T.E. N. V. motor, wound for 220-440 V., 3 phase, 60 cycle. Heating is furnished by eight Hevi-Duty furnace sections. A section consists of an upper and lower portion each with an electrical capacity of 7.5 KW. Each portion is provided with a separate control thermocouple so that the upper and lower heating elements are individually controlled. Heating elements are operated on a maximum of 120 volts. Insulation consists of 2-1/2" Armstrong fire brick and 2" Superex on bottom and 3-1/2" Superex and 1-1/2" 85% magnesia on top.

Procedure For Drying Out Reactor Furnaces

1. Check for the following:

   a. Block valves around pressure relief valves in the gas inlet bypass lines must be open.

   b. Expansion joints connecting gas lines to the reactor must be free to move.

2. The furnace sections, as received, have not been dried out. Before being subjected to operating temperatures, the furnaces must be allowed to heat up slowly. The schedule recommended by the manufacturer is as follows:

   a. Control at 400°F for eight hours.

   b. Control at 600°F for the next six hours.

   c. Control at 1000°F for the next four hours.

   The above times are minimum and may be lengthened if desired. After the initial sixteen hours, the furnaces are ready for use at any temperature up to 1200°F.

H-7 Partial Condenser Two Required

JS-262-4 Drawing No. 1553

Matt. Corcoran and Company

Vertical, shell and tube type surface condenser; 16" O.D. x 6'4" high; stress relieved; gas on tube side; inlet gas connection 4" schedule 40 seamless pipe; outlet connection 3" schedule 40 seamless pipe; all metal in contact with process gas and fluid is Monel; constructed in accordance with A.S.M.E. P U-68. Shell fabricated of steel pipe; design pressure 50 psi; design temperature 200°F; test pressure 60 psi; asbestos gaskets; corrosion allowance 1/8". Sixty 3/4" x 5' 0" Monel #10 BWG tubes, single pass, welded in 1-1/4" Monel tube sheets; test pressure 60 psi; design temperature 900°F; copper gaskets; segmented baffles fabricated of 3/16" steel.

H-9 Still Feed Tank One Required

JS-262-5 Drawing No. F-896-8 Rev. C

Industrial Process Engineers

Unit is horizontally mounted, cylindrical vessel, dished ends, 71" long and 4' 0" O.D.; capacity 500 gallons. Material of construction - Monel. Vessel has two 3" nozzles in top; also, 16" manhole in top equipped with 6" flange; two drain nozzles in bottom; a 2" nozzle which is flush with the bottom; and a 1" nozzle which extends 3" above the bottom. Operating temperature 180°F; design pressure 5 psi internal, 15 psi external; corrosion allowance 0.125"; stress relieved. Constructed in accordance with A.S.M.E. Code P U-68. No heat required, 1" 85% Magnesia insulation.

H-10 | HF Distillation Tower | One Required

JS-262-6 | Drawing No. F-896-5 Rev. B and C-896-15

Industrial Process Engineers

Material of construction - Monel. Unit has overall length of 14' 9"; distillation tower is made of 8-5/8" outside diameter Monel pipe and consists of an upper section (5' 7") and a lower section (6'2"); reboiler is 3' - 0" high and made of 14" outside diameter Monel pipe. Tower is packed with 8' - 0" of 1/2" Monel Raschig rings. Tower is heated by six 1000 watt, 5' - 0" long, Chromalox heaters, TI-6034XX, equally spaced around the circumference of each of the two column sections (12 heaters in all); electrical service is 440 V., 3 phase, 60 cycle. Reboiler is heated by 24 Chromalox, 2500 watt strip heaters #SE-3001XX, 30-1/2" overall length, 3 phase, 60 cycle, 230 V. Insulation consists of 3" thick, Rockwool Blanket in removable sections. All flanged connections are modified Sargol joint. Operating temperature 230°F; design pressure 5 psi internal, 15 psi external; corrosion allowance 0.125". Built in accordance with A.S.M.E. code P U-68; stress relieved.

H-11 | Reflux Condenser | One Required

JS-262-7 | Drawing No. A-14559 Rev. 1

The Whitlock Manufacturing Company

Shell and tube type water cooled surface condenser; 5' 3-15/16" long by 10-1/2" outside diameter. Condenser contains sixteen 3/4" outside diameter x 10 BWG, 3' long Monel tubes. All metal in contact with process gas is Monel. Process gas passes through tube side. Gas inlet - 2" schedule 40 Monel pipe; gas outlet - 1" schedule 40 Monel pipe; condensate drain - 1" schedule 40 Monel pipe; water connections - 1-1/4" screwed steel coupling. Corrosion allowance 0.125" except on tubes. Design conditions on tube side; pressure - 5 psi internal; 15 psi external; temperature - 300°F; hydrostatic test pressure - 25 psi; Teflon packing. Shell fabricated of 6" schedule 40 steel pipe. Baffles fabricated of 1/8" Monel with Monel tie-rods. Design conditions on shell side; pressure - 50 psi; temperature - 200°F; hydrostatic test - 100 psi; corrosion allowance 1/8". Total empty weight 415#. All construction in accordance with A.S.M.E. Code P U-68.

H-12	Centrifugal Blower	Two Required
JS-262-8	Drawing No. B-11205	
	The Spencer Turbine Company	

Constructed of steel; flanged 3" inlet-outlet connections; Teflon gasket material; 200 CFM at 19" H_2O pressure; electric motor 1.5 H.P., 3500 RPM, 440 volts, 3 phase, 60 cycles; operating temperature 200°F. Blower casing heated with a 1630 watt, 147 V, 9/16" diameter, 12' long calrod and enclosed in a 1" thick 85% magnesia insulation housing. Blower is equipped with an Elliott Compressor type viscosity plate seal using nitrogen as the buffer gas.

H-13	NaF Trap	Two Required
F-10		Two Required
JS-262-9	Drawing No. C-896-1, Rev. B	
	Industrial Process Engineers	

Made of 12" I.D. steel pipe; overall length 4' 10-1/4". Standard 12" blind flange on one end and 1/2" drain coupling on other end. Heated by six Chromalox SE-4301XX, 1500 watt heaters connected two in series on 3 phase, 460 V. circuit; sectional insulation is 3" thick Unibestos. Inlet is 1" pipe on side near bottom; outlet is 1" pipe on opposite side near top. A thermocouple well is located in the side 24" below the top flange. Design pressure 5 psi internal, 15 psi external; operating temperature 600°F. Constructed in accordance with A.S.M.E. code P U-68; stress relieved.

H-14	Azeotrope Cooler	One Required
JS-262-10	Drawing No. AWP-11543-3	
	Carbide & Carbon Chemicals Division	

Pipe cooler consisting of a 10' section of 2" schedule 40 Monel pipe jacketed with a 3" schedule 40 steel pipe. Unit is equipped with a 3" Adsco Piston Ring Expansion Joint #S-152 PG. Water connections are 1" screwed couplings. Jacket test pressure - 150 psi.

H-17	UO_2 Feed Hopper	Three Required
	Drawing No. AK-1389 Z31 C-107119	
	Link-Belt Company Fairbanks, Morse & Company	

Made of 1/4" Monel, 2-1/2' x 2-1/2' square, 3' 8-3/4" long, approximately 10 cu.ft. capacity; slopes on two sides and front to a 17" discharge along length of screw. Two openings on top-a 1' opening provided with a 6" type "T" Gemco valve for powder feed and a 3" opening for inspection. Provided with baffles to prevent powder bridging; contains a sliding gate to seal off powder from screw in case screw has to be removed. Feed hopper and screw assembly rest on a scale provided by Fairbanks, Morse & Company; pipe lever type, net capacity 6250 pounds; scale is equipped with a Taylor pneumatic indicating transmitter which transmits weight to a recorder in control room and with mercoid to actuate alarms.

H-31 UO_2 Screw Three Required

Drawing No. AK-1389 Z8
AK-1389 Z34

Link-Belt Company

Material of construction - Monel; screw is 3-7/16" diameter, 6' 5-3/4" long, with a 2" pitch; shaft diameter 1-5/8"; encased in a 3-1/2" Monel pipe; 32 RPM = approximately 0.5 ft^3 in two minutes. Drive is a VM-2 P.I.V., 4-1 ratio - maximum output speed 1720 RPM, minimum output speed 430 RPM - 1-1/2 H.P. motor; motor is connected by a #7 FT Falk controlled torque coupling to a 35.04 to 1 worm gear reducer. Screw shaft is packed with copper foil. Heat is provided by a Hevi-Duty, type M-5036-S tube furnace 3-1/2' long with five thermocouple openings; 10 KW, 120 volts, 2 phase.

H-40 Scrubber One Required

Drawing No. AWP-12624-1

Carbide & Carbon Chemicals Division

All Monel construction; unit consists of a schedule 40, 6" diameter Monel pipe, 2'6" long; a 2" coupling on bottom for liquid drain; a 2" inlet coupling on side of pipe, 4" from the top; a 6" blind flange on top of unit; a 1/4" G-10, Sprayco, Monel spray nozzle inside unit, 4" from top.

F-3 Primary Cooler Two Required

JS-262-13 Drawing No. A-14560-Rev. 1

The Whitlock Manufacturing Company

Hairpin type water cooler with gas on tube side. Cooler is 6' 8-5/8" long and 14-5/8" in diameter. Gas inlet connection - 4", outlet - 3", schedule 40 Monel pipe. There are 30 tubes, 3/4" outside diameter x 14 BWG Monel, approximately 11-1/2' long with a hairpin bend. All metal in contact with process gas is Monel. Design conditions on tubes, pressure - 5 psi internal, 15 psi external; temperature - 900°F, hydrostatic test - 25 psi. Shell is 10-3/4" outside diameter steel pipe with 10 segmented 1/8" thick brass baffles. Water connections are 1-1/4" screwed couplings. Design conditions on shell; pressure - 50 psi; temperature - 200°F; hydrostatic test - 100 psi. Corrosion allowance 0.125" except on tubes. Cooler constructed in accordance with A.S.M.E. code P U-68.

F-4 Primary Compressors Two Required

JS-262-14 Drawing No. 2D-5696

Roots-Connersville Blower Corporation

Positive displacement pump. Aluminum casing, aluminum impellers and Monel shaft. 3" flanged connections; maximum volume 100 CFM; suction pressure 0 psig; discharge pressure 2 psig; operating temperature 150°F. Electric motor 3 H.P., 440 volt, 3 phase, 60 cycle. Packing is braided copper-impregnated Teflon with nitrogen buffer. Pump casings are heated with 1000 watt, 230 volt, 1/2" diameter 3-1/2' long calrod heaters, and enclosed in a 1" thick 85% magnesia insulation housing.

F-1 Gas Mixing Chamber One Required

JS-262-12 Drawing No. D-896-9 Rev. C

Industrial Process Engineers

Unit is a cylindrical vessel, dished ends, 3' 3-1/2" long, 18" O.D.; capacity 5.3 ft^3. Material of construction - steel. Operating temperature 200°F; internal pressure 5 psi, external 15 psi; corrosion allowance 0.125". Constructed in accordance with A.S.M.E. code P U-68; stress relieved. Vessel is mounted vertically with three gas inlets located on top side, one 3", one 2", and the other 1". A 3" outlet is located on the bottom. Vessel is equipped with two 4" inspection flanges located on side 180° apart. Vessel is supported by three steel legs spaced 120° apart. No heat required, 1" of 85% magnesia insulation.

F-2 F_2 Reactors Three Required

Drawing No. AK-1389 Z20

Link-Belt Company

Reactors are 30' 4" long x 26" wide x 6" high; 1/2" thick. Conveyor is attached to drive mechanism by eight 4" schedule 80 Inconel pipe welded to sides and bottom of Monel trough. Seven sets of 4 leg Forward reactors. Two sets of 4 leg Return reactors. Drive is a H-4 P.I.V., FD-254 electric fluid drive with 5 H.P., 1750 RPM, T. E. N. V. motor would for 220-440 V., 3 phase 60 cycle operation. Heating is provided by six Hevi-Duty furnace sections which consist of an upper and a lower portion, each provided with a separate heating element and control thermocouple so that the heat generated by upper and lower heating elements is individually controlled. Upper and lower half of each section has a capacity of 7.5 KW at 120 volts. Insulation consists of 2-1/2 Armstrong Fire Brick and 2" Superex on bottom section and 3-1/2" Superex and 1-1/2" 85% magnesia on top.

F-7	Secondary Cooler	Three Required
JS-262-15	Drawing No. AWP-11554-2	
	Carbide & Carbon Chemicals Division	

Pipe water cooler consisting of a jacketed 1" schedule 40 Monel pipe 18' long, jacket fabricated of 2" schedule 40 steel pipe. Equipped with a 2" Adsco Piston Ring Expansion Joint #S-152. Water connections are 1" screwed couplings. Test pressure on jacket - 150 psi.

F-8	Secondary Compressors	Two Required
JS-262-16	Drawing No. 2D-5687	
	Roots-Connersville Blower Corporation	

Positive displacement pump, aluminum casing, and impellers with Monel shaft. Maximum volume 20 CFM; suction pressure 0 psig; discharge pressure 2 psig; operating temperature 150°F; 2" Monel flanged connections. Pump casings are lagged with 1000 watt, 230 volt, 1/2" diameter, 3-1/2' long calrod heaters. Pump casings are enclosed in a 1" thick 85% magnesia insulation housing. Electric motor 3/4 H.P., 440 volt, 3 phase, 60 cycle. Braided copper-impregnated Teflon packing with nitrogen buffer.

F-13 Ash Receiver Three Required

Drawing Nos. D-40312, D-40316, D-40310, D-40311, D-40320

Carbide & Carbon Chemicals Division

A 24" diameter x 31-1/4" high x 1" thick steel shield into which is fitted a 30 gallon feed drum. The 30 gallon drum is equipped with a gasketed steel adapter which has a 5-10/32" diameter x 12-1/4" long nozzle. The shield is equipped with a steel flange cover which seals the adapter to the 30 gallon drum. The adapter is equipped with a steel cap and yoke to seal the container. Entire receiver assembly is supported by a dolly suspended from a Howe Platform Scale. Receivers are used in a pit which is heated by six 3000 watt, 460 volt, 3 phase Chromalox No. EH 2407. Heaters mounted on the wall.

F-13-S Ash Receiver Sacle Three Required

Drawing No. N-46759

Howe Scale Company

Lever type scale; maximum scale load 3400 pounds; scale rating 4500 pounds; maximun net load 1000 pounds; primary tare load 600 pounds; secondary tare load 1800 pounds; scale chart capacity 1000 pounds x 1 pound; tare beam capacity 2500 pounds, main capacity beam 2000 pounds x 500 pounds; fractional tare beam 500 pounds x 2 pounds; drop weights 1000 pounds; accuracy ± 0.1% of full dial scale reading = ± 1.0 pound. Dial 20" in diameter; center-line elevation of dial 5' - 0" from floor; cabinet dimensions 10" x 36" x 45". Alarm contact and leads 5.0 amperes at 120 V., 60 cycle. Relays, etc. 120 V., 60 cycle. Accuracy ± 1.0% of full dial scale reading.

F-14 UF_4 Feed Hopper Three Required

Drawing No. AK-1389 Z36
D-107155

Link-Belt Company
Fairbanks, Morse & Company

Made of 1/4" Monel, 1' 4" x 1' 2" x 1' 1-3/4"; apprriximately 1.5 cu.ft. capacity. Slopes on two sides discharging into a 3" diameter Monel pipe. Two openings on top, a flanged 6" diameter Monel pipe welded at a 60° angle to hopper for powder feed, and a flanged 3" diameter Monel pipe, 3-1/2" long, for inspection purposes. Hopper and screw assembly are supported on a Fairbanks, Morse & Company scale, pipe lever type, 500 pounds capacity. No heat or insulation required.

F-15 UF_4 Screw Three Required

Drawing No. AK-1389 Z8
AK-1389 Z34

Link-Belt Company

Material of construction - Monel; screw is 2-15/16" diameter, 2' 10-5/8" long, with a 1-1/4" pitch; shaft diameter 1-7/16"; housed in a 3" diameter Monel pipe. Drive is a HM-1/2, P.I.V. 4-1 ratio - maximum output speed 1750 R.P.M. - 3/4 H.P. motor; motor is connected by a #5 FT Falk controlled torque coupling to a 282.75 to 1 gear reducer. Screw shaft packing is copper foil. No heat or insulation required.

F-5	Primary Cold Trap	Six Required
F-9	Secondary Cold Trap	Three Required

Drawing No. 416-A 779-C

Kellex Corporation

Unit consists of an outer and an inner shell, both made of copper. Outer shell 19" O.D. x 10' 9" long x 1/4" thick; with insulation 32-5/8" O.D.; inlet and outlet heads made of Monel. Inner shell is a 10" O.D. copper tube, 3/8" wall; contains a 4-1/2" copper gas return pipe which, in turn, contains a 2-1/4" O.D. gas exhaust tube made of Monel. Shell design pressure; internal - 40 psi, external - 15 psi; test pressure external - 60 psi, internal 15 psi; design temperature 160°F. Refrigerant is CO_2; flows in parallel pipes outside outer shell; flows inside inner shell around 4-1/2" gas return pipe; refrigerant design pressure 300 psia, test pressure 428 psia, design temperature 160°F maximum,-55°F minimum. Outer shell is heated by two 4320 watt calrods, maximum temperature 700°F, 440 V; inlet head 200 watt calrod, maximum temperature 500°F, 110 volts; outlet head 575 watt calrod, maximum temperature 500°F, 110 volts. Inner shell is heated by 100 watts insertion calrod, maximum temperature 200°F, 110 volts, and a 5080 watt calrod maximum temperature 500°F, 440 volts. Vessel is mounted horizontally with a slope of 1"/ft.

F-6	Dust Filter	Three Required

Drawing No. D-40287-3

Carbide & Carbon Chemicals Division

Unit consists of an upper cylinder, a lower cylinder and tube assembly. Upper cylinder is made of 16" diameter, schedule 20 nickel-plated steel; it is 7" long and contains a 2" flanged Monel gas outlet. Lower cylinder is made of 16" diameter, schedule 20 nickel-plated steel and is 5' 4-1/4" long; gas enters this cylinder through a 1" schedule 40 Monel pipe with flanged connections. Tube assembly consists of 120 barrier tubes, and bottom and top tube plates to contain the tubes; barrier tubes are 5' standard tubes plugged at bottom ends; upper tube plate made of Monel, 18" O.D. x 3/4" thick; bottom tube plate made of Monel, 15-1/4" O.D. x 1/4" thick; tube plates are fastened with three 1" diameter, 64" long Monel tie-rods; upper tube plate has standard 1" eye bolt in order to remove assembly when required; upper tube plate is bolted between the two cylinders. Gaskets are 1/8" aluminum wire, 16-3/4" O.D. Overall length of unit is 6' 0". Operating pressure 0-18 psia. Hydrostatic test pressure 30 psi. Six calrod heaters rated at 300 watt, 230 V each are wound around the lower cylinder. One inch 85% magnesia insulation.

F-19 UF$_6$ Cylinder Three Required

Drawing No. KE-300-J-03-B-C

Kellex Corporation

29-3/16" I.D. x 81-1/2" long, wall thickness of 13/32", head thickness of 3/4" with concave radius of 29-1/4"; water capacity of 1601.1 pounds; test pressure of 500 psi. Built under ICC Shipping Container Specification 106A500. Equipped with two chlorine institute valves for ton containers.

F-19H Feed Vaporizer Heater Three Required

Drawing No. D-AWP-12357-0

Carbide & Carbon Chemicals Division

Equipment consists of a vaporizer heater which uses recirculated air as a heat transfer medium between finned electrical elements and the vaporizer cylinder; room air to cool the vaporizer cylinder and heater unit can also be circulated. Heat is supplied by six, 2000 watt, 230 volt, 3 phase, finned strip heaters. Air is circulated by an American Blower Company Sirocco No. 105 set steel housing; capacity @70°F is 1600 cfm, @ 3/4" W.G.; 2H.P. motor; suitable for operating at 350°F. Insulation is blanket type mineral gray slagwool, suitable for 350°F.

F-19-S Feed Vaporizer Scale Three Required

JS-262-38 Toledo Scale Company

Lever type scale; maximum scale load 8500 pounds; maximum operating load 7500 pounds; dial scale 2000 pounds with 2.0 pounds graduation markings. Accuracy $\pm$ 1.0% of full dial scale reading, $\pm$ 2.0 pounds.

Smooth steel platform 4' by 6'.

Dial 20" in diameter; center line elevation of dial 5' above floor; dial head mounted on 6' side of platform; 2' 6" clearance between center line of platform and dial head.

Automatic device mounted on back or side of scale head to print numerical weight in pounds.

Electrical specifications 110 V. A-C 60 cycles.

F-20 Alumina Trap One Required

Vessel made of 3/8" carbon steel; overall length 5-1/2', 2' outside diameter at widest point. Gas entrance pipe is a 6" flanged connection; 1-1/2" exhaust gas outlet; a 1/2" nitrogen inlet is provided. A dump gate at bottom is used for emptying; manhole at top of vessel is used for recharging trap. One thermocouple well is provided. Hydrostatic test pressure 100 psig; design temperature 650°F. Filled with activated alumina. No heat or insulation required.

Reference: Kellex Operating Manual, Vol. XL, page 67 and Figure IV-2-10.

F-21	Vacuum Pump	One Required

Standard Beach-Russ 50 cfm, Series 50, class D, type RP MFL oil filled mechanical vacuum pump with mist filter assembly. Pump is 30" wide, 36" long, 36" high.

F-22	Alumina Trap	Two Required
F-36	Alumina Trap	Two Required

Fabricated of standard 12" schedule 40, Cadmium coated, steel pipe; traps are 40" high, and are equipped with standard 12" blind flanges on top, a 3/4" inlet on bottom side and a 3/4" outlet on the top side. Traps are filled with activated alumina.

F-37	Vacuum Pump	One Required

International Machine Works, No. 6, 4 cu.ft. International Vacuum Pump with guard belt. Approximate weight 130 pounds; 23" long x 14" wide x 15" high; 1/3 H.P. motor.

F-38 Dust Separator Three Required

JS-262-40 Drawing No. JN-C 6296 Rev. A

Nooter Corporation

Unit is Monel tank mounted vertically in gas outlet line; 1' 3/4" O.D. x 2' 4-1/2" long; contains baffles to drop dust back on reactor tray; a 2" outlet in side near top and a 3" flanged outlet in bottom; working pressure 5 psi and full vacuum, hydrostatic test 10 psi; corrosion allowance 1/8"; maximum allowable temperature 900°F; tank stress relieved per C&CCD specification JS-262-34. No heat required. One inch Superex insulation.

F-39 Tank One Required

JS-258-94 Drawing Nos. AWP-12578-2
100-F-75-AB, 100-M-02-AA-2, 100 M-02-AA-1

Carbide & Carbon Chemicals Division

Kellex Corporation

Eight feet I.D. x 22 ft. long elliptical head tank mounted horizontally; 10% nickel clad; design pressure,30 psi - internal; 15 psi - external; design temperature 220°F; hydrostatic test pressure 90 psi, air test pressure 30 psi; stress relieved and X-rayed; fabricated in accordance with A.S.M.E. P U-68. Tank is traced with 1" copper steam lines and insulated. Two 16" nozzles are located on top of tank. One is reduced to 1" and is equipped with a plug; the other is reduced to 2" and connected to the Process line. End of tank is equipped with a 16" nozzle which is plugged and a 4" nozzle which is reduced to1/2" and is connected to an air purge line.

F-41 Fume Scrubber One required

Drawing No. D-AWP-12690-0

Carbide & Carbon Chemicals Division

All metal in contact with process gas or liquid is Monel. Unit consists of two sections, an upper and lower, bolted together. Upper section made of 16 gauge Monel, 24" diameter, 66" long, extend inside lower section 19". Lower section made of 12 gauge Monel, 30" diameter, overall length 49". Upper section provided with two 1/2" Monel bar stock nozzles, 19/64" orifice, rated at 3.6 GPM @ 15 psig (water): one nozzle located 2" from top of unit, other 34" from top. Gas enters at top through a 12" diameter opening; scrubbed gas leaves at upper part of bottom section, passing over an eliminator blade assembly and discharging through a 12" diameter opening. Asight glass is provided 24" from bottom of unit at operating level; sight glass is 1/16" thick P-10, 4-1/2" outside diameter. Liquid circulation is provided by an Eastern centrifugal pump, model F, type 100.

Bellows Connectors

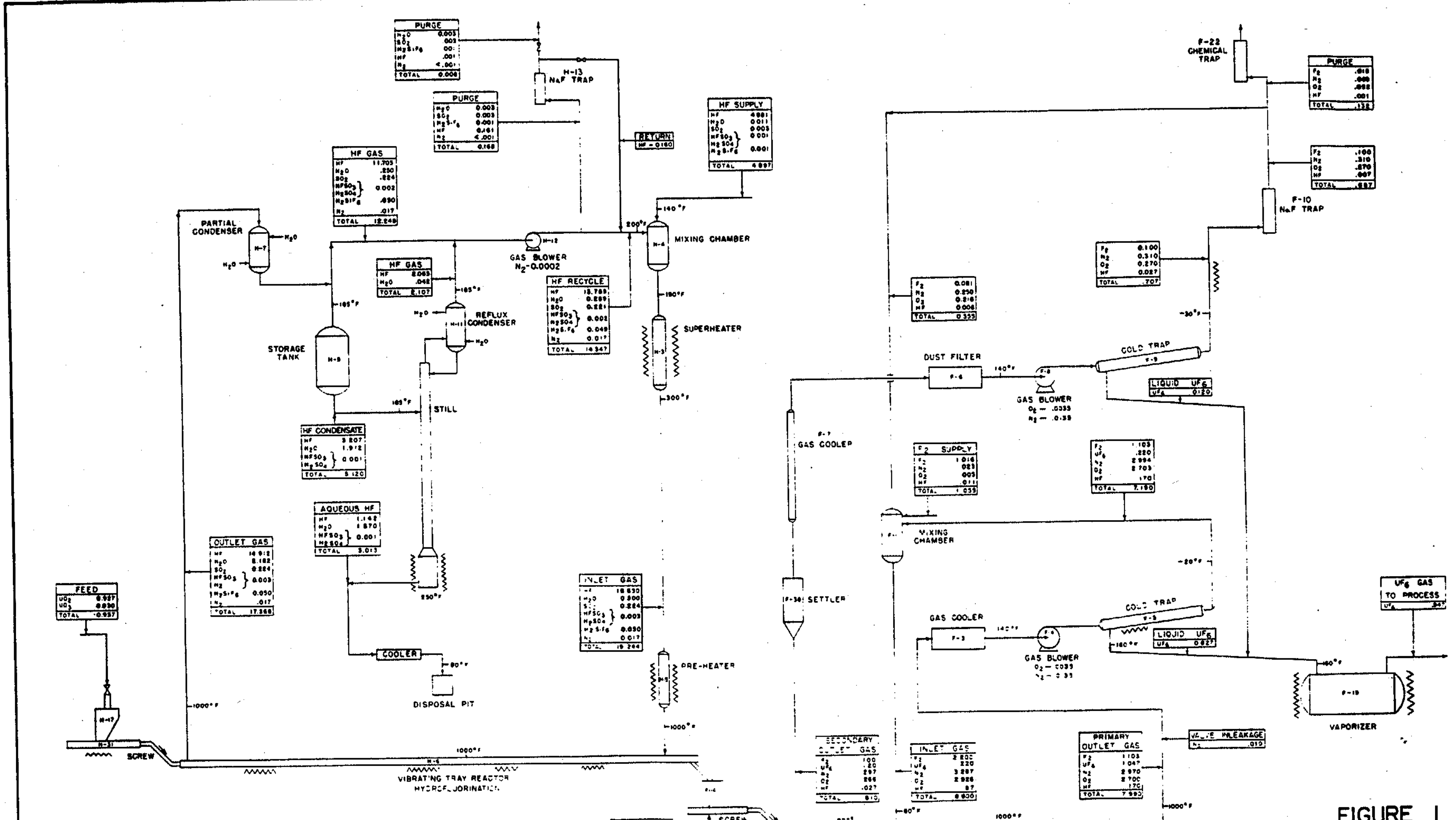
JS-262-11
JS-262-43

All connectors consist of two concentric bellows welded at each end to a 1" thick carbon steel (SAE 1040) flange. A connection is provided in one flange to permit buffering the space between the bellows. All outer bellows are made of stainless steel. The connectors for HF service have Inconel inner bellows. Those for F_2 service have Monel inner bellows. The connectors for powder service have a Monel sleeve liner. The scale deflection bellows are made of .018" thick material. These bellows have the same diameter at both ends, and are mounted on 10" diameter flanges. The vibration and adsorption bellows are made of .031" material. The vibration adsorption bellows for powder service have a tapered diameter, with the smaller diameter at the vibrating end, and are mounted on 10" diameter flanges. The vibration and expansion bellows for gas service also have tapered diameters, with the smaller diameter at the moving end. The smaller end is mounted on a 10" diameter flange, while the larger end is mounted on an 11" diameter flange. The specifications for the bellows materials are as follows:

Stainless steel #304, maximum carbon 0.08%. 2D finish on one side. Deep drawing quality.

Inconel - ASTM specification B-168. Deep drawing quality.

Monel - ASTM specification B-127. Deep drawing quality.



BASIS: POUND MOLS / HR FOR 8000 LBS UF6 / DAY
PLANT DESIGN IS FOR 110 PER CENT OF QUANTITIES SHOWN

FIGURE I

CARBIDE AND CARBON CHEMICALS DIVISION
K-25 ENGINEERING DEVELOPMENT DIVISION

MATERIAL BALANCE FLOW DIAGRAM

ENGINEER: R.M. Vail	APP'D BY:
DRAFTSMAN: R.M. Duggan	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-769-4

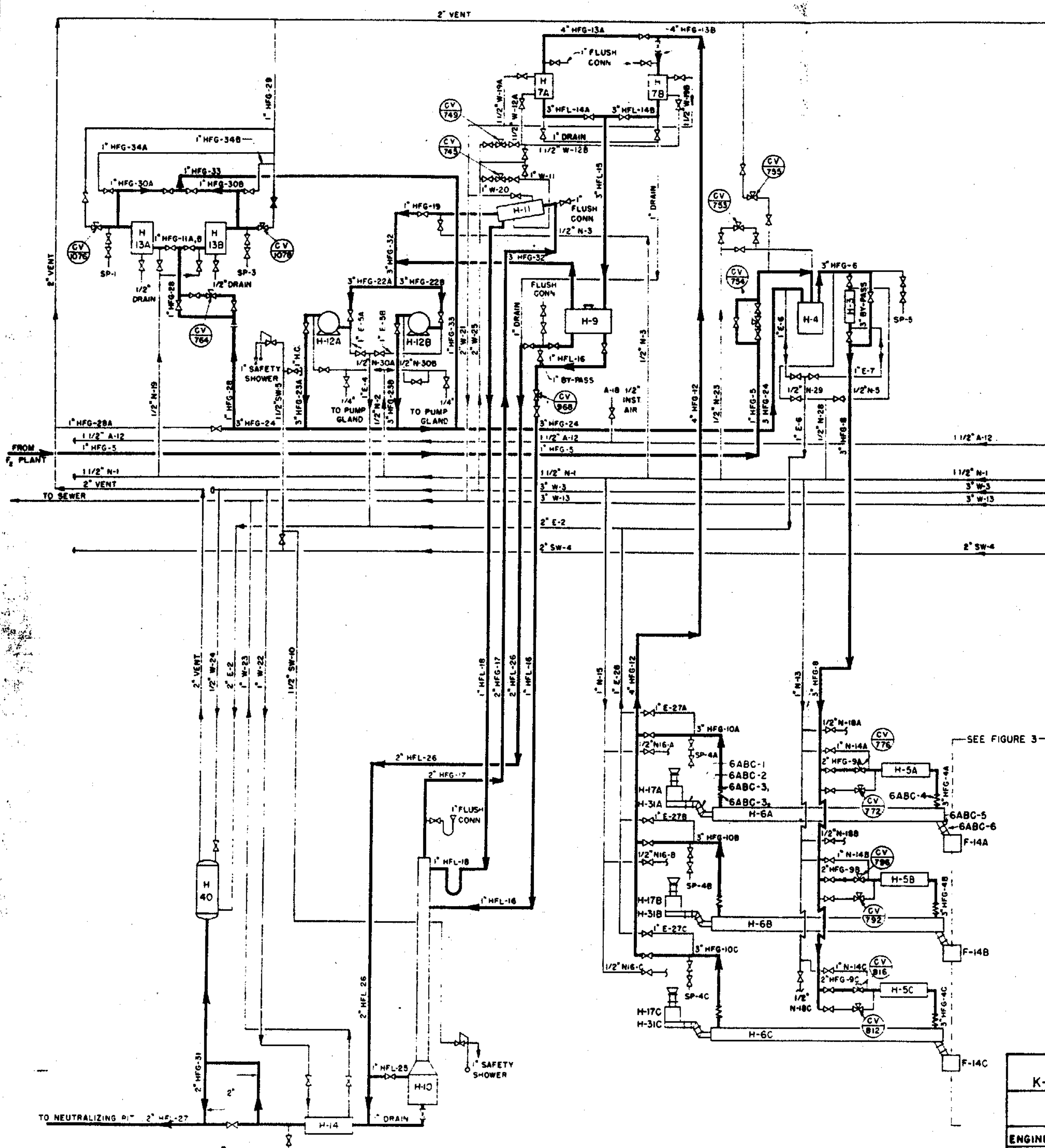


FIGURE 2

EQUIPMENT LIST

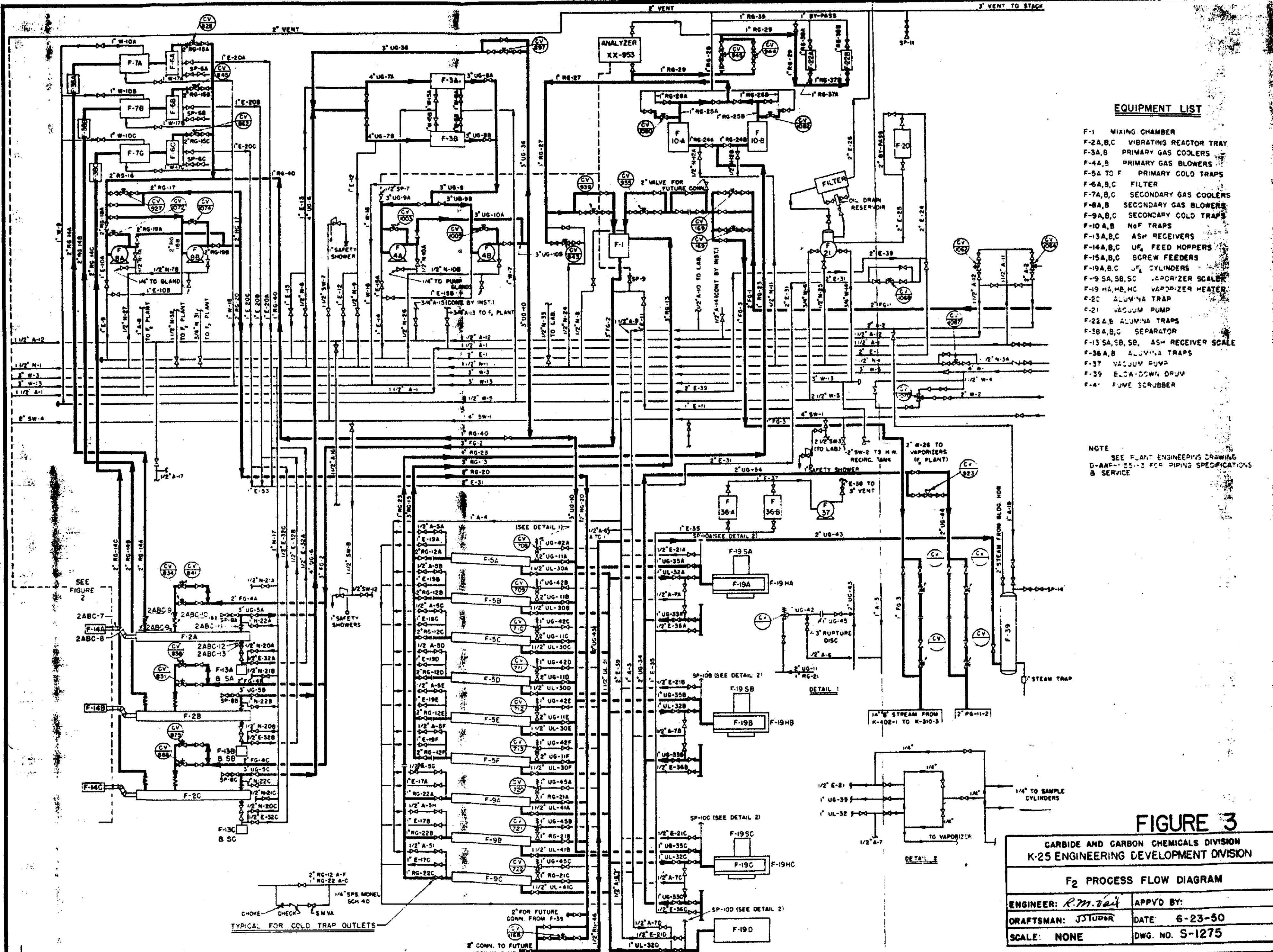
H-3 SUPERHEATER
H-4 MIXING CHAMBER
H-5A,B,C PREHEATERS
H-6A,B,C VIBRATING REACTOR TRAYS
H-7A,B CONDENSERS
H-9 HOLD TANK
H-10 DISTILLATION COLUMN
H-11 REFLUX CONDENSER
H-12A,B RECIRCULATING GAS BLOWERS
H-13A,B NoF TRAPS
H-14 AZEOTROPE COOLER
H-17A,B,C UO_2 FEED HOPPERS

H-31A,B,C CONVEYORS
H-40 SCRUBBER
6A,B,C 1 TO 6 INCLUSIVE-HF TRAY BELLOWS
F-14 A,B,C UF_4 FEED HOPPERS

NOTE:
SEE PLANT ENGINEERING DRAWING D-AWP-11551-3 FOR PIPING SPECIFICATIONS AND SERVICE.

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
HF PROCESS FLOW DIAGRAM	
ENGINEER: R.M. Vail	APPV'D BY
DRAFTSMAN: JJ Tuber	DATE 6-23-50
SCALE: NONE	DWG. NO. S-1274

142


EQUIPMENT LIST
F-1 MIXING CHAMBER
F-2A,B,C VIBRATING REACTOR TRAY
F-3A,B PRIMARY GAS COOLERS
F-4A,B PRIMARY GAS BLOWERS
F-5A TO F PRIMARY COLD TRAPS
F-6A,B,C FILTER
F-7A,B,C SECONDARY GAS COOLERS
F-8A,B SECONDARY GAS BLOWERS
F-9A,B,C SECONDARY COLD TRAPS
F-10 A,B NaF TRAPS
F-13A,B,C ASH RECEIVERS
F-14A,B,C UF4 FEED HOPPERS
F-15A,B,C SCREW FEEDERS
F-19A,B,C UF6 CYLINDERS
F-9 SA,SB,SC VAPORIZER SCALES
F-19 HA,HB,HC VAPORIZER HEATER
F-20 ALUMINA TRAP
F-21 VACUUM PUMP
F-22A,B ALUMINA TRAPS
F-38A,B,C SEPARATOR
F-13 SA,SB,SB, ASH RECEIVER SCALE
F-36A,B ALUMINA TRAPS
F-37 VACUUM PUMP
F-39 BLOW-DOWN DRUM
F-41 FUME SCRUBBER
NOTE
SEE PLANT ENGINEERING DRAWING D-ANF-1251-3 FOR PIPING SPECIFICATIONS & SERVICE
TYPICAL FOR COLD TRAP OUTLETS
DETAIL 1
DETAIL 2
FIGURE 3
CARBIDE AND CARBON CHEMICALS DIVISION
K-25 ENGINEERING DEVELOPMENT DIVISION
F2 PROCESS FLOW DIAGRAM
ENGINEER: R.M. Vail
APPV'D BY:
DRAFTSMAN: J.J.TUDOR
DATE: 6-23-50
SCALE: NONE
DWG. NO. S-1275

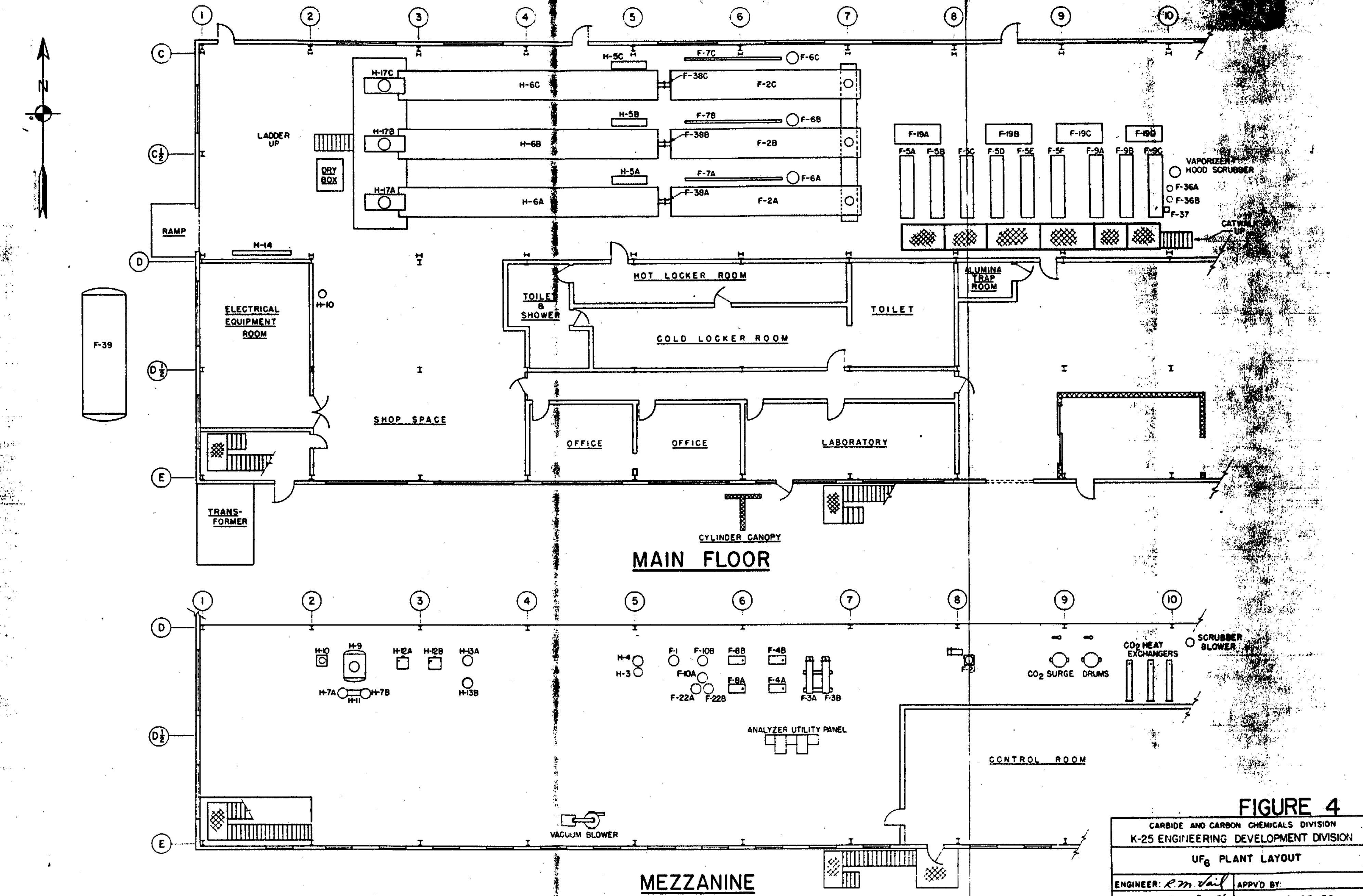


FIGURE 4

CARBIDE AND CARBON CHEMICALS DIVISION
K-25 ENGINEERING DEVELOPMENT DIVISION
UF_6 PLANT LAYOUT

ENGINEER: R. M. Vail	APPV'D BY:
DRAFTSMAN: R. T. Lowell	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1276

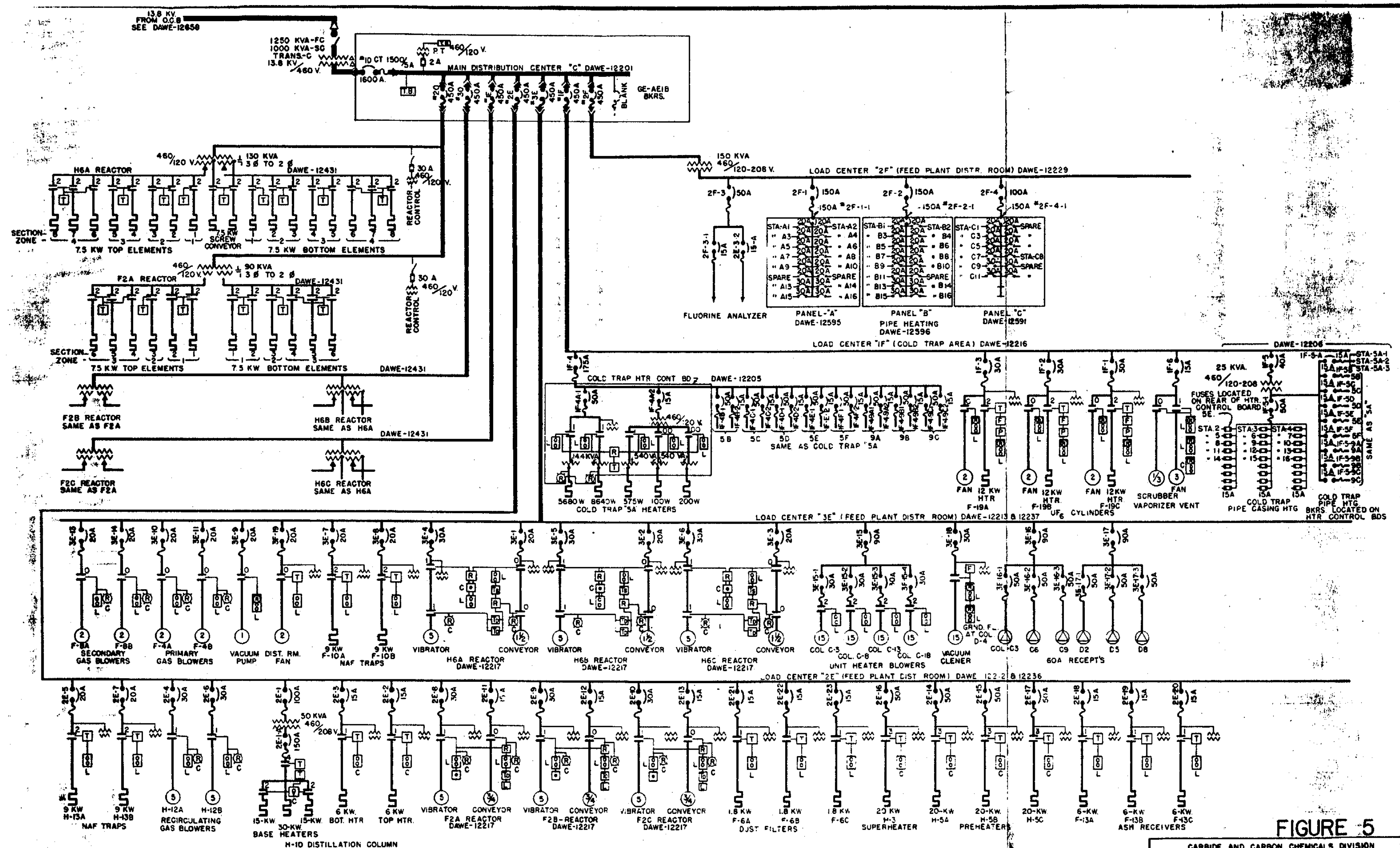
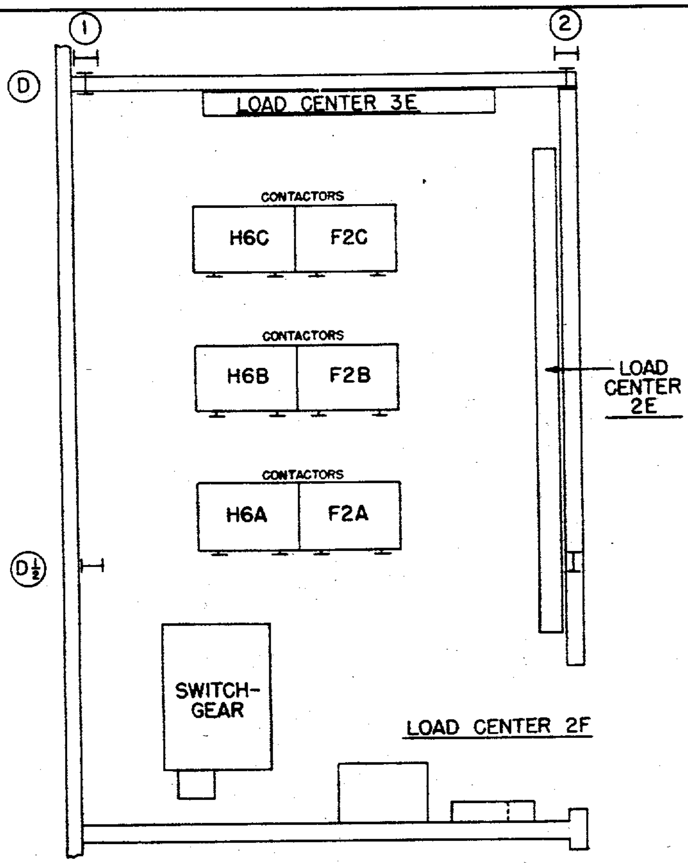


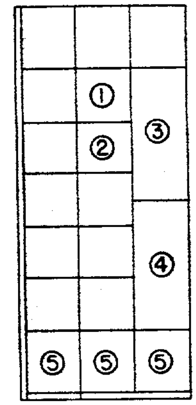
FIGURE 5

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
ELECTRICAL DISTRIBUTION DIAGRAM	
ENGINEER: R M Vail	APPV'D BY:
DRAFTSMAN: R.M. [illegible]	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1277

115



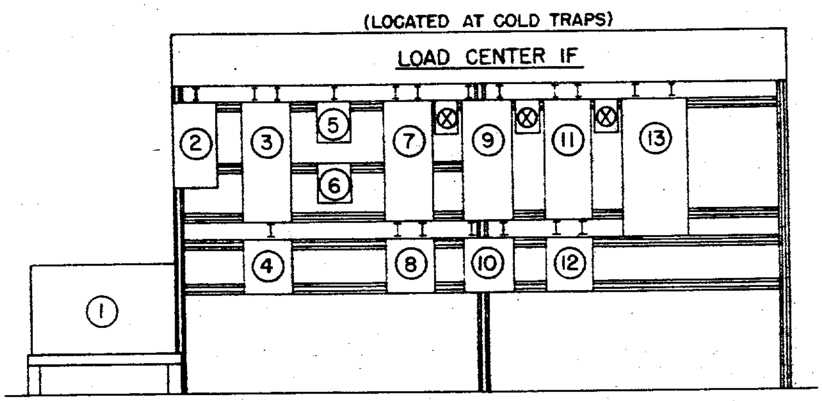
PLOT PLAN
(MAIN DISTRIBUTION ROOM)



LOAD CENTER 2F

KEY

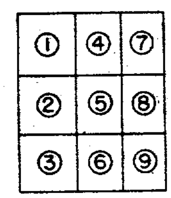
1 2F-3 F_2 ANALYZER
2 2F-4 HEATER PANEL "C"
3 2F-1 HEATER PANEL "A"
4 2F-2 HEATER PANEL "B"
5 PULL BOX



⊗-CONTROL TRANSFORMER

KEY

1 25 KVA. TRANSFORMER 460/120/208 V.
2 1F-5 TRANSFORMER PRIMARY
3 1F-6 VAPORIZER
4 1F-6A SCRUBBER
5 1F-5-1 VACUUM PUMP
6 1F-5-2 MAIN CONTROL SWITCH
7 1F-1 HEATERS
8 1F-1A FAN
9 1F-2 HEATERS
10 1F-2A FAN
11 1F-3 HEATERS
12 1F-3A FAN
13 1F-4 MAIN SWITCH C. T. HEATERS



SWITCH-GEAR

KEY

1 1D-TRANSFORMER SECONDARY
2 1E-TRANSFORMER H6C & F2C
3 1F-LOAD CENTER
4 2D-TRANSFORMER H6A & F2A
5 2E-LOAD CENTER
6 2F-LOAD CENTER
7 3D-TRANSFORMER H6B & F2B
8 3E-LOAD CENTER
9 3F-BLANK

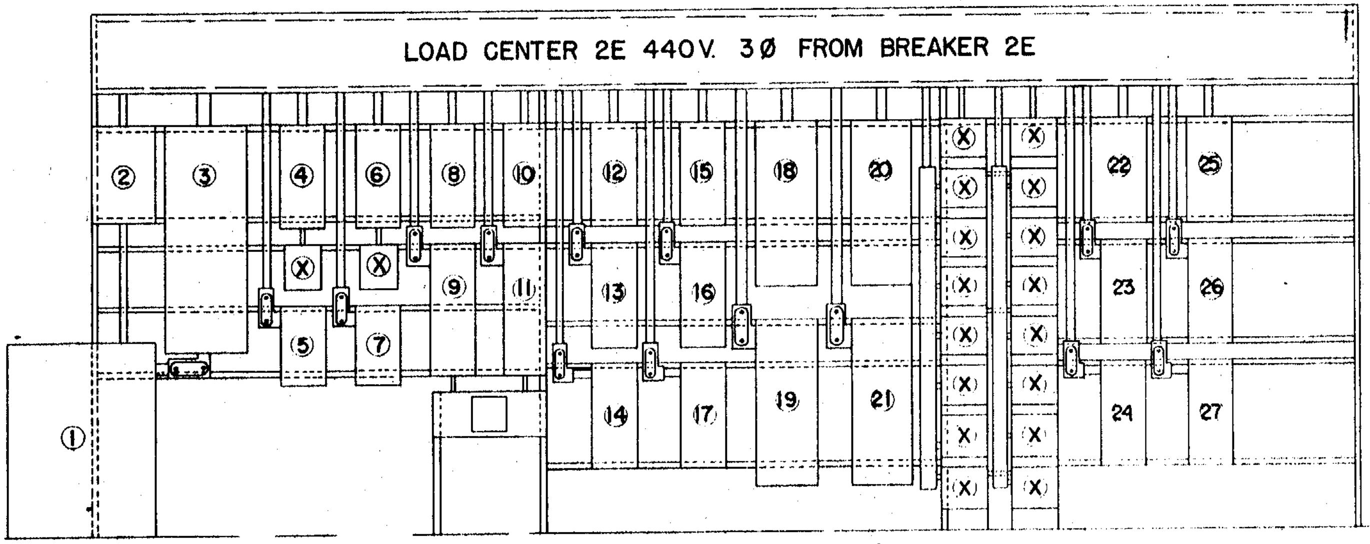
FIGURE 6

CARBIDE AND CARBON CHEMICALS DIVISION
K-25 ENGINEERING DEVELOPMENT DIVISION

SWITCH GEAR & LOAD CENTERS, 2F & 1F

ENGINEER: R. M. Vail	APPV'D BY:
DRAFTSMAN: R. M. Angevine	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1278

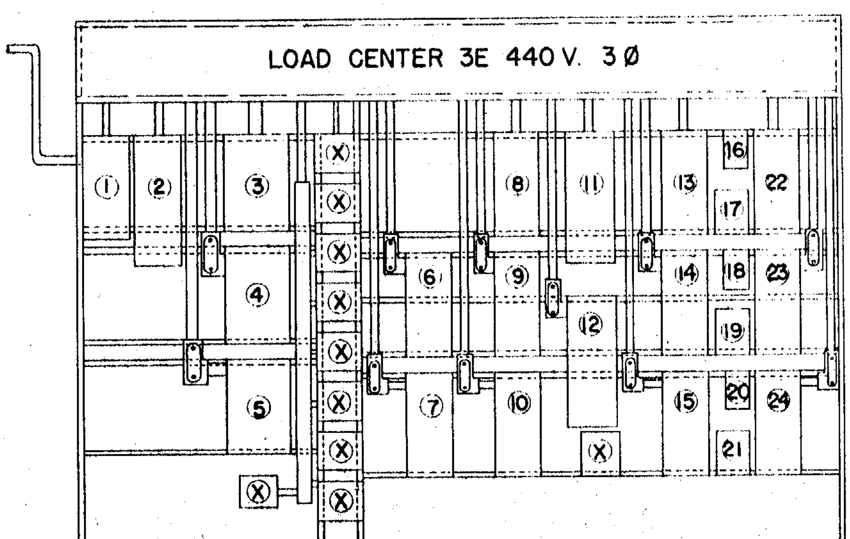
146



X - CONTROL TRANSFORMERS

KEY

1 50 KVA TRANSFORMER 440-208/120 3Ø
2 2E-1 TRANSFORMER DISCONNECT
3 2E-1A DISTILLATION COLUMN H-10
4 2E-2 H-10 DISTILLATION COLUMN
5 2E-1A1 DISTILLATION COLUMN H-10
6 2E-3 H-10 DISTILLATION COLUMN
7 2E-1A2 DISTILLATION COLUMN H-10
8 2E-4 RECIRCULATING GAS BLOWER H-12A
9 2E-5 NaF TRAP H-13A
10 2E-6 RECIRCULATING GAS BLOWER H-12B
11 2E-7 NaF TRAP H-13B
12 2E-8 VIBRATOR F-2A
13 2E-9 VIBRATOR MOTOR F-2B
14 2E-10 VIBRATOR MOTOR F-2C
15 2E-11 SCREW CONVEYOR F-2A
16 2E-12 SCREW CONVEYOR F-2B
17 2E-13 SCREW CONVEYOR F-2C
18 2E-14 PREHEATER H-5A
19 2E-15 PREHEATER H-5B
20 2E-16 SUPERHEATER H-3
21 2E-17 PREHEATER H-5C
22 2E-18 ASH RECEIVER F-13A
23 2E-19 ASH RECEIVER F-13B
24 2E-20 ASH RECEIVER F-13C
25 2E-21 DUST FILTER F-6A
26 2E-22 DUST FILTER F-6B
27 2E-23 DUST FILTER F-6C



X - CONTROL TRANSFORMERS

KEY

1 3E-19 DISTRIBUTION ROOM FAN
2 3E-18 VACUUM CLEANER
3 3E-15 UNIT HEATERS & COND. PUMP
4 3E-16 60 A. RECEPTACLE COL. LINE "C"
5 3E-17 60 A. RECEPTACLE COL. LINE "D"
6 3E-13 SECONDARY GAS BLOWER F8-A
7 3E-14 SECONDARY GAS BLOWER F8-B
8 3E-9 VACUUM PUMP F-21
9 3E-10 PRIMARY GAS BLOWER F4-A
10 3E-11 PRIMARY GAS BLOWER F4-B
11 3E-7 NaF TRAP F-10A
12 3E-8 NaF TRAP F-10B
13 3E-4 VIBRATOR MOTOR H6A
14 3E-5 VIBRATOR MOTOR H6B
15 3E-6 VIBRATOR MOTOR H6C
16 3E-1-1 VIBRATOR MOTOR H6A-CONTACTOR
17 3E-4-1 VIBRATOR MOTOR H6A-CONTACTOR
18 3E-2-1 VIBRATOR MOTOR H6B-CONTACTOR
19 3E-5-1 VIBRATOR MOTOR H6B-CONTACTOR
20 3E-3-1 VIBRATOR MOTOR H6C-CONTACTOR
21 3E-6-1 VIBRATOR MOTOR H6C-CONTACTOR
22 3E-1 SCREW CONVEYOR H6A
23 3E-2 SCREW CONVEYOR H6B
24 3E-3 SCREW CONVEYOR H6C

FIGURE 7

CARBIDE AND CARBON CHEMICALS DIVISION
K-25 ENGINEERING DEVELOPMENT DIVISION

LOAD CENTERS 2E & 3E

ENGINEER: R.M. Tait	APPV'D BY:
DRAFTSMAN: R.M. Angerme	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1279

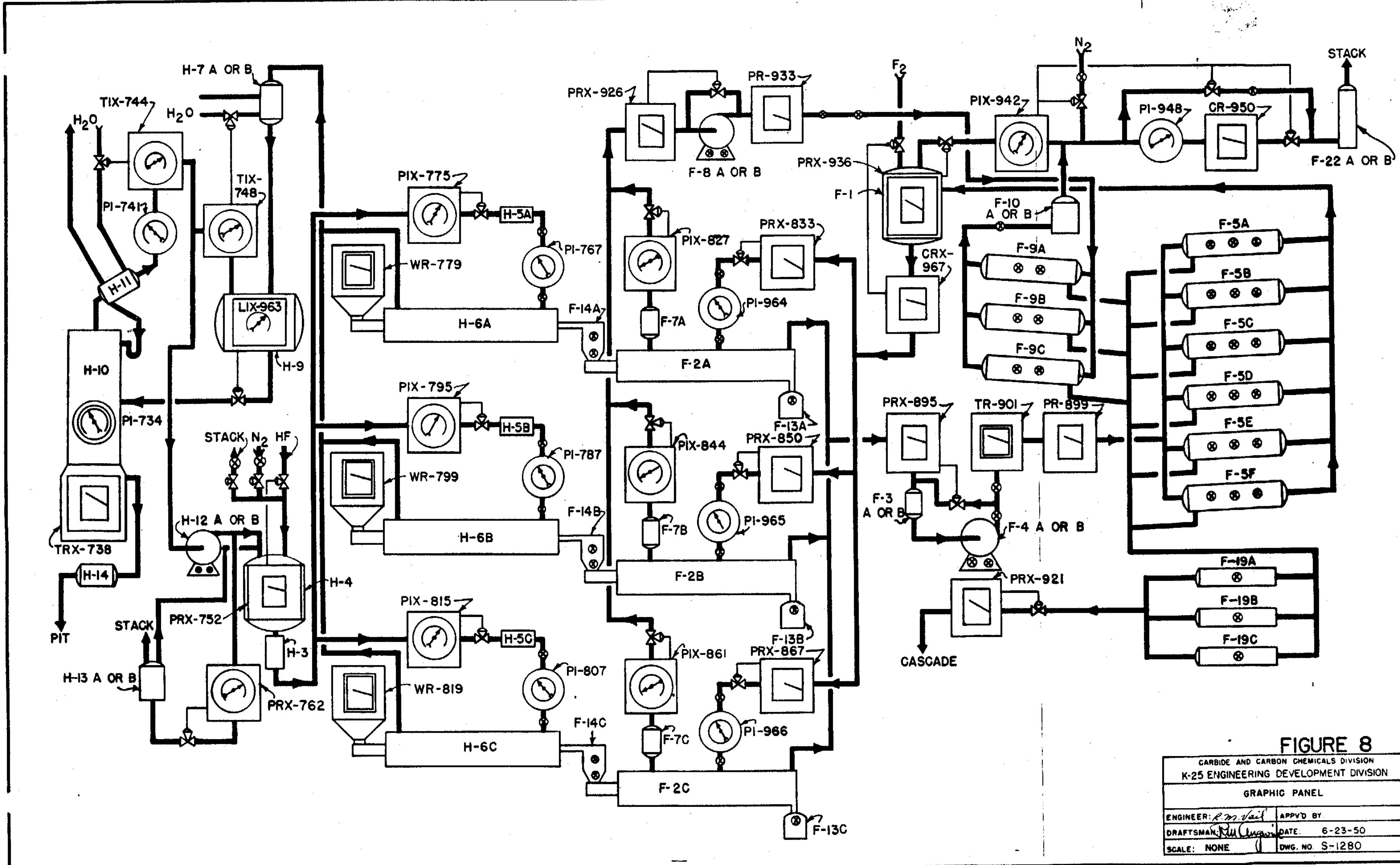
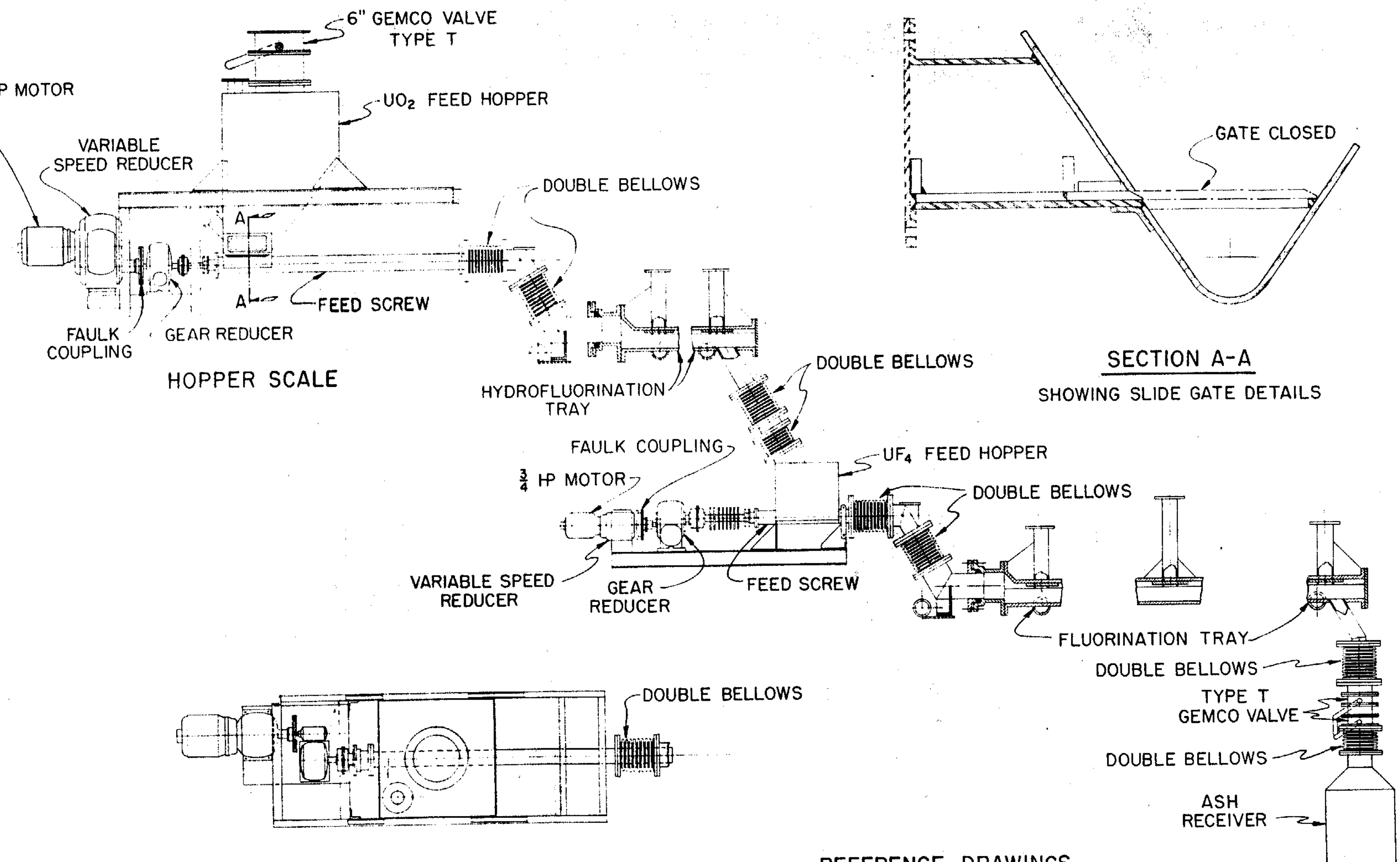


FIGURE 8

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
GRAPHIC PANEL	
ENGINEER: R. M. Vail	APPV'D BY
DRAFTSMAN: [illegible]	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1280



PLAN VIEW OF HOPPER SCALE

REFERENCE DRAWINGS

LINK-BELT COMPANY
ATLANTA, GEORGIA

UF_4 FEED HOPPER – DWG. AK 1389Z36
UO_2 FEED HOPPER – DWG. AK 1389Z31
FEED SCREWS – DWG. AK 1389Z34

FIGURE 9

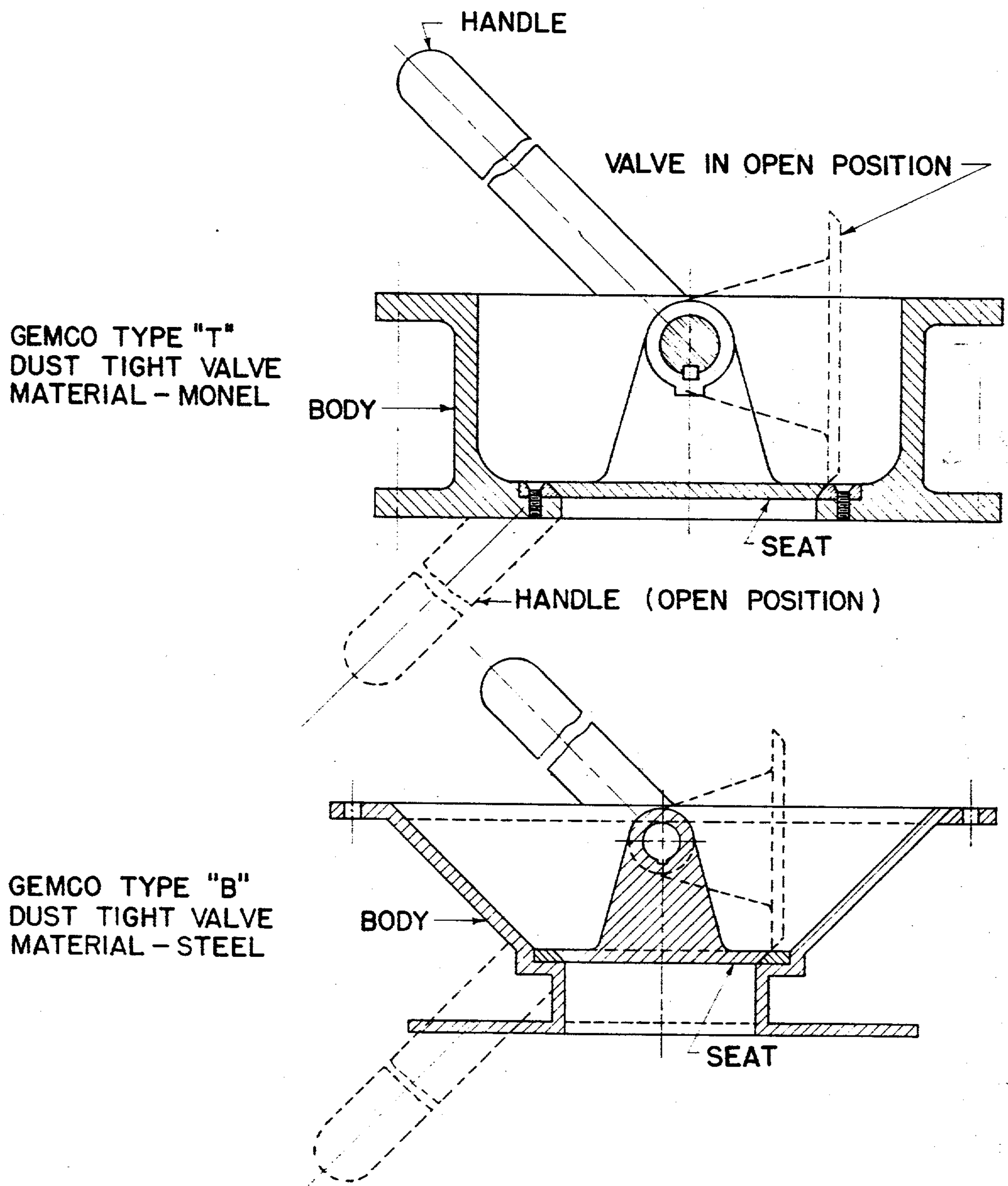
CARBIDE AND CARBON CHEMICALS DIVISION
K-25 ENGINEERING DEVELOPMENT DIVISION

SOLIDS FLOW SYSTEM

ENGINEER: R. M. Vail	APP'VD BY
DRAFTSMAN: [illegible]	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1281

S-1281

149



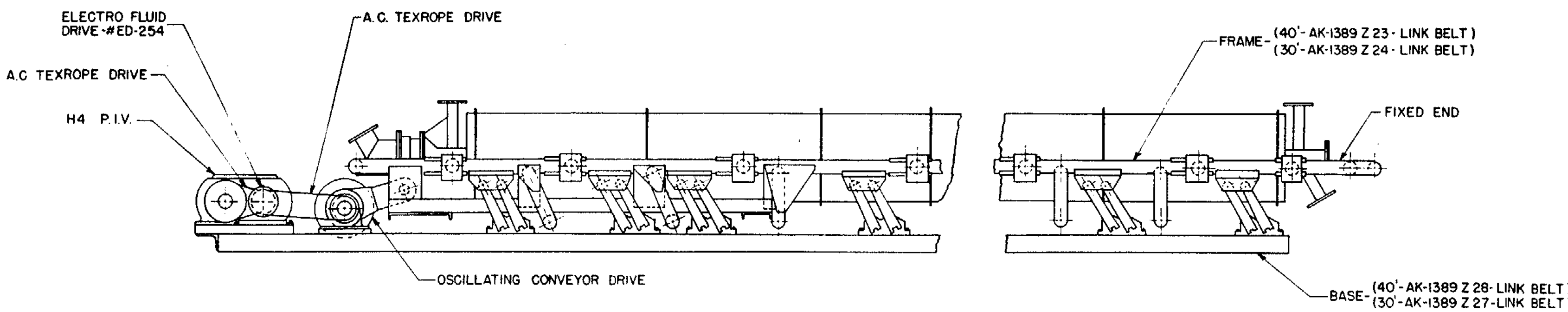
REFERENCE DRAWINGS

GENERAL MACHINE CO.
NEWARK 5, N.J.

DWG. C-502 SHEET 1 (TYPE "T")
DWG. M-2235 (TYPE "B")

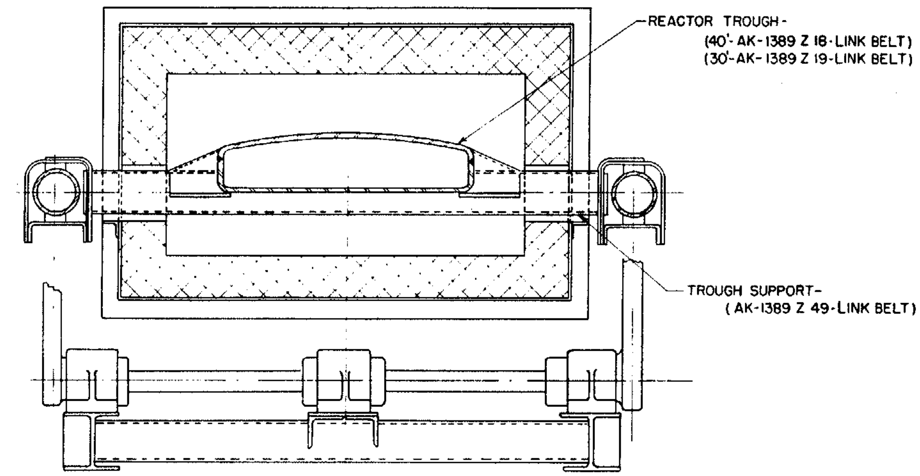
FIGURE 10

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
GEMCO DUST-TIGHT POWDER VALVES	
ENGINEER: R.M. Vail	APPV'D BY:
DRAFTSMAN: [illegible]	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1282



REACTOR SPECIFICATIONS

	30'	40'
MATERIAL	½" MONEL	½" INCONEL
DESIGN TEMP.	1000°F	1000°F
DESIGN PRESS.	± 3 p.s.i.	± 3 p.s.i.
HYDROSTATIC TEST	7¼ p.s.i.	7¼ p.s.i.
AIR TEST	5 p.s.i.	5 p.s.i.
STRESS RELIEF	1200°F FOR 1 HR.	1200°F FOR 4 HRS.



TYPICAL SECTION THROUGH FURNACE

REFERENCE DRAWINGS:

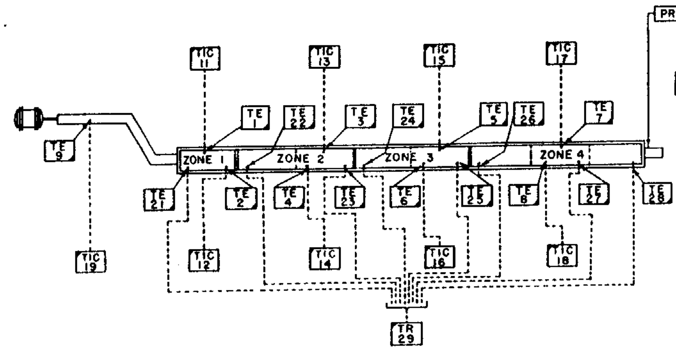
LINK-BELT CO.
ATLANTA, GA.
AK-1389 Z 12
AK-1389 Z 20

HEVI-DUTY ELECTRIC CO.
MILWAUKEE, WISCONSIN
NO. 7006-A
NO. 7006-B

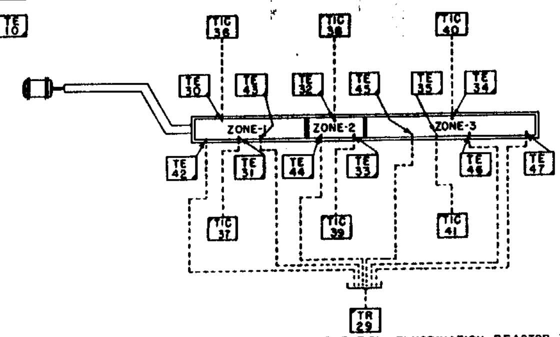
S-1283

FIGURE 11

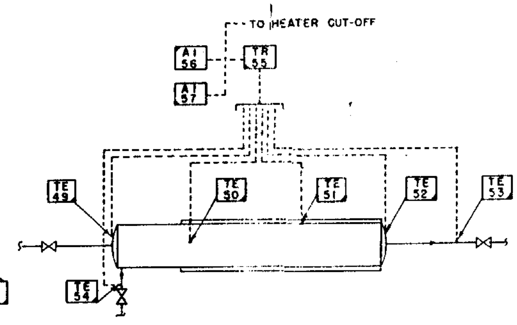
CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
REACTOR & DRIVE ASSEMBLY	
ENGINEER: R.M. Vail	APP'VD BY:
DRAFTSMAN: R.T. Powell	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1283



TYPICAL TEMP. INSTRUMENTATION - HYDROFLUORINATION REACTOR TRAYS



TYPICAL TEMP. INSTRUMENTATION - FLUORINATION REACTOR TRAYS

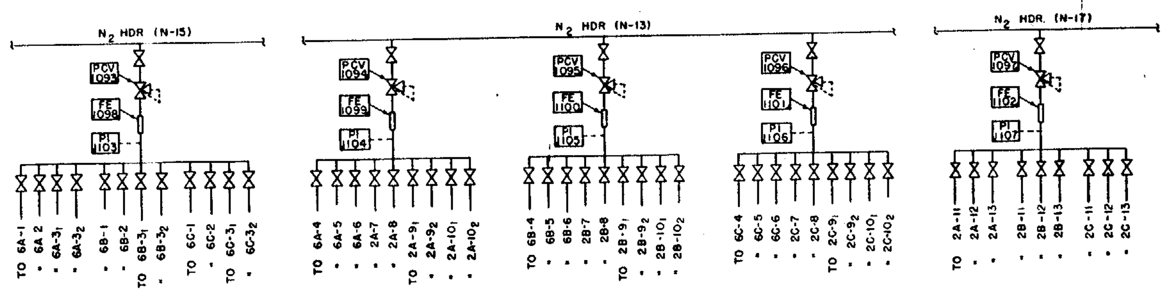


TYPICAL COLD TRAP TEMP. INSTRUMENTATION

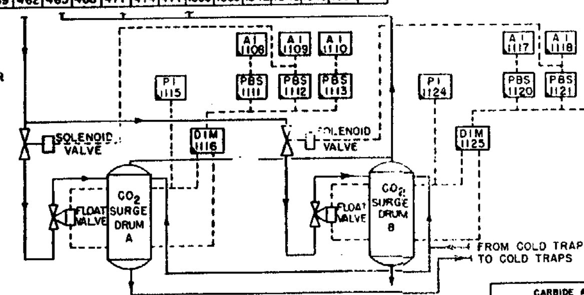
TRAP NO.	APP. REFERENCE FOR COLD TRAPS								
	TE 49	TE 50	TE 51	TE 52	TE 53	TE 54	TR 55	AI 56	AI 57
F-5A	334	335	336	337	338	975	339	885	876
F-5B	340	341	342	343	344	976	339	886	877
F-5C	345	346	347	348	349	977	339	887	878
F-5D	350	351	352	353	354	978	355	888	879
F-5E	356	357	358	359	360	979	355	889	880
F-5F	361	362	363	364	365	980	355	890	881
F-9A	366	367	368	369	370	981	371	891	882
F-9B	372	373	374	375	376	982	371	892	883
F-9C	377	378	379	380	381	983	371	893	884

TRAY NO	APP. REFERENCE FOR HYDROFLUORINATION REACTOR TRAY																												
	TE 1	TE 2	TE 3	TE 4	TE 5	TE 6	TE 7	TE 8	TE 9	TE 10	TIC 11	TIC 12	TIC 13	TIC 14	TIC 15	TIC 16	TIC 17	TIC 18	TIC 19	TIC 20	TE 21	TE 22	TE 23	TE 24	TE 25	TE 26	TE 27	TE 28	TR 29
H-6A	382	385	388	391	394	397	400	403	406	409	412	415	418	421	424	427	430	433	436	439	1010	1013	1016	1019	1022	1025	1028	1031	1052
H-6B	383	386	389	392	395	398	401	404	407	410	413	416	419	422	425	428	431	434	437	440	1011	1014	1017	1020	1023	1026	1029	1032	1053
H-6C	384	387	390	393	396	399	402	405	408	411	414	417	420	423	426	429	432	435	438	441	1012	1015	1018	1021	1024	1027	1030	1033	1054

TRAY NO	APP. REFERENCE FOR FLUORINATION REACTOR TRAY																	
	TE 30	TE 31	TE 32	TE 33	TE 34	TE 35	TIC 36	TIC 37	TIC 38	TIC 39	TIC 40	TIC 41	TE 42	TE 43	TE 44	TE 45	TE 46	TE 47	TR 29
F-2A	442	445	448	451	454	457	460	463	466	469	472	475	1034	1037	1040	1043	1046	1049	1052
F-2B	443	446	449	452	455	458	461	464	467	470	473	476	1035	1038	1041	1044	1047	1050	1053
F-2C	444	447	450	453	456	459	462	465	468	471	474	477	1036	1039	1042	1045	1048	1051	1054



BELLOWS BUFFER SYSTEM INSTRUMENTATION

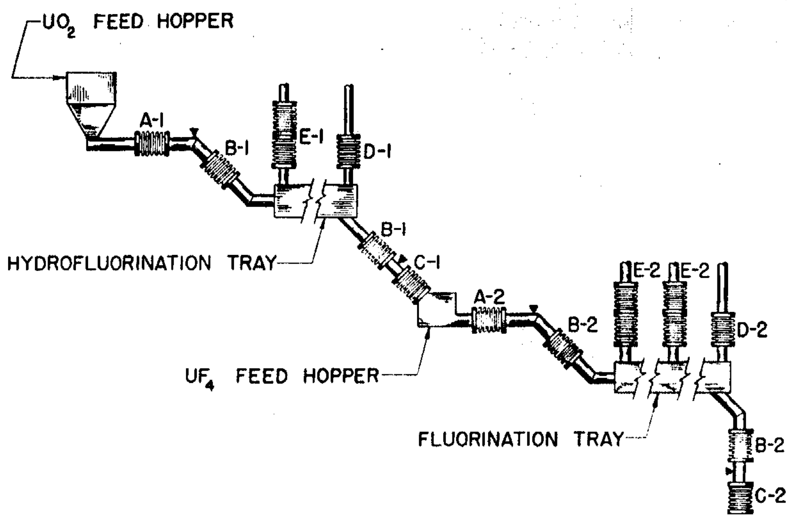


COLD TRAP REFRIGERANT SYSTEM

FIGURE 12

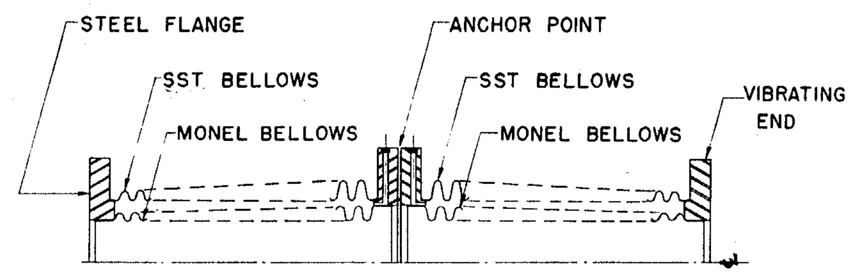
CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
SPECIAL INSTRUMENTATION	
ENGINEER:	APPR'D BY:
DRAFTSMAN:	DATE 6-23-50
SCALE: NONE	DWG NO S-1284

BELLOWS	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2	E-1	E-2
AVERAGE TEMPERATURE °F.	800	800	1000	1000	1000	800	800	1000	800	1000
SERVICE-OSCILLATING			YES	YES			YES	YES	YES	YES
SERVICE-EXPANSION							YES	YES	YES	YES
SERVICE-SCALE DEFLECTION	YES	YES			YES	YES				
FREQUENCY CYCLES/MINUTE			700 1000	700 1000			700 1000	900	700 1000	900

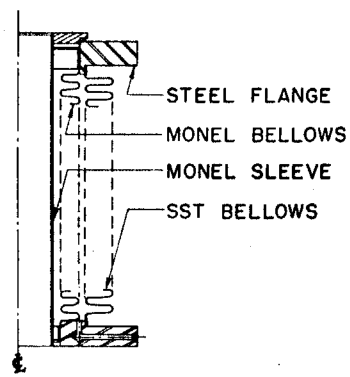


ALL BELLOWS TEST PRESSURE 4 1/2 P.S.I. AIR

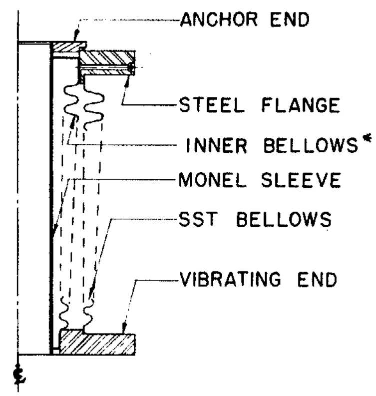
DESIGN SPECIFICATIONS



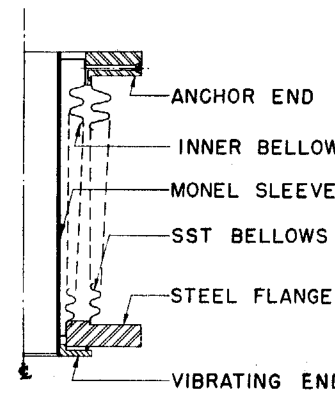
E-1 (HALF E-1 IS D-1)
E-2 (HALF E-2 IS D-2)



A-1 & 2
C-1 & 2
NOTE: NO MONEL SLEEVE IN A-1 & A-2



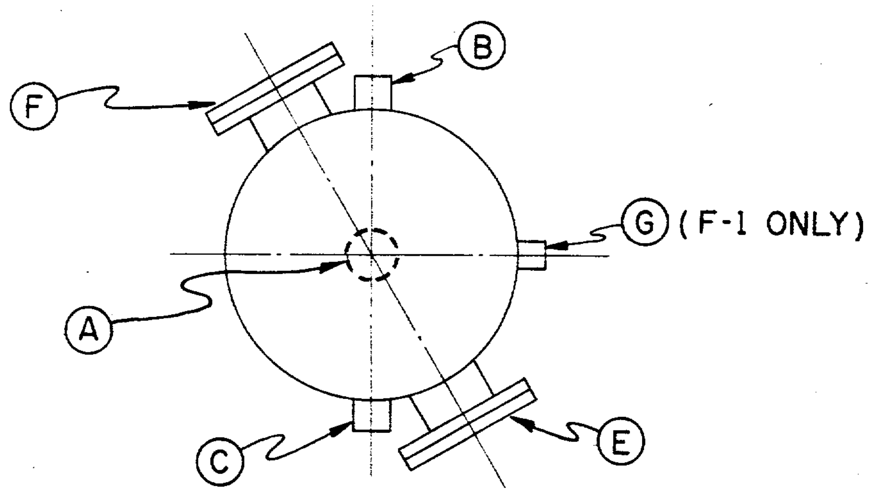
B-1 * INCONEL
B-2 * MONEL



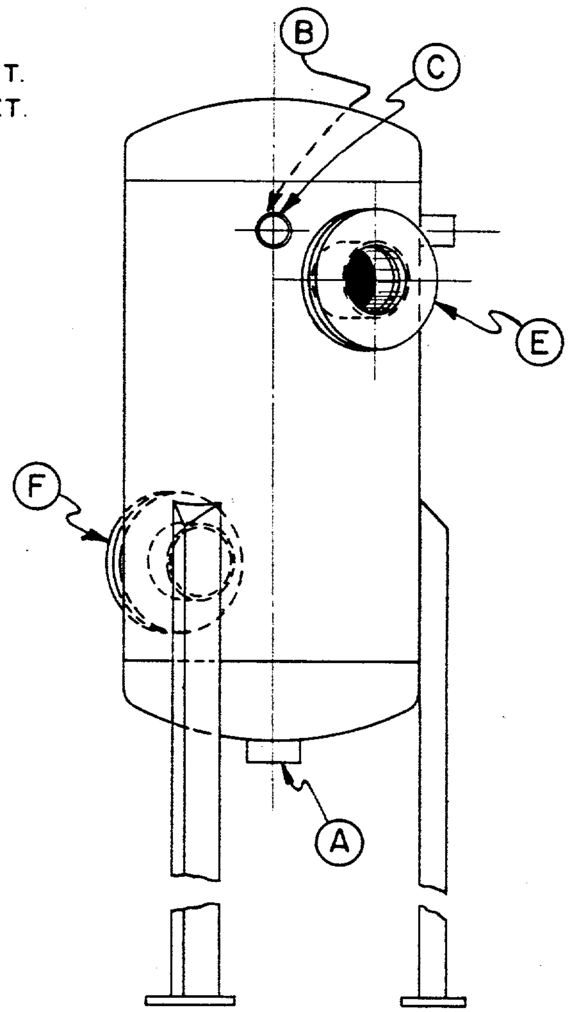
B-1 * INCONEL
B-2 * MONEL

FIGURE 13

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
BELLOWS CONNECTORS	
ENGINEER: R. M. Vail	APP'VD BY:
DRAFTSMAN: J. J. TUDOR	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1285



U-68 CODE VESSEL
DESIGN PRESS.----5p.s.i.g. INT.
15p.s.i.g. EXT.
OPER. TEMP.---- 200°F
CAPACITY ---- 5.3 cu. ft.
CORR. ALLOW.---- $\frac{1}{8}$"
MATERIAL---- F-1 -- STEEL
H-4 -- MONEL



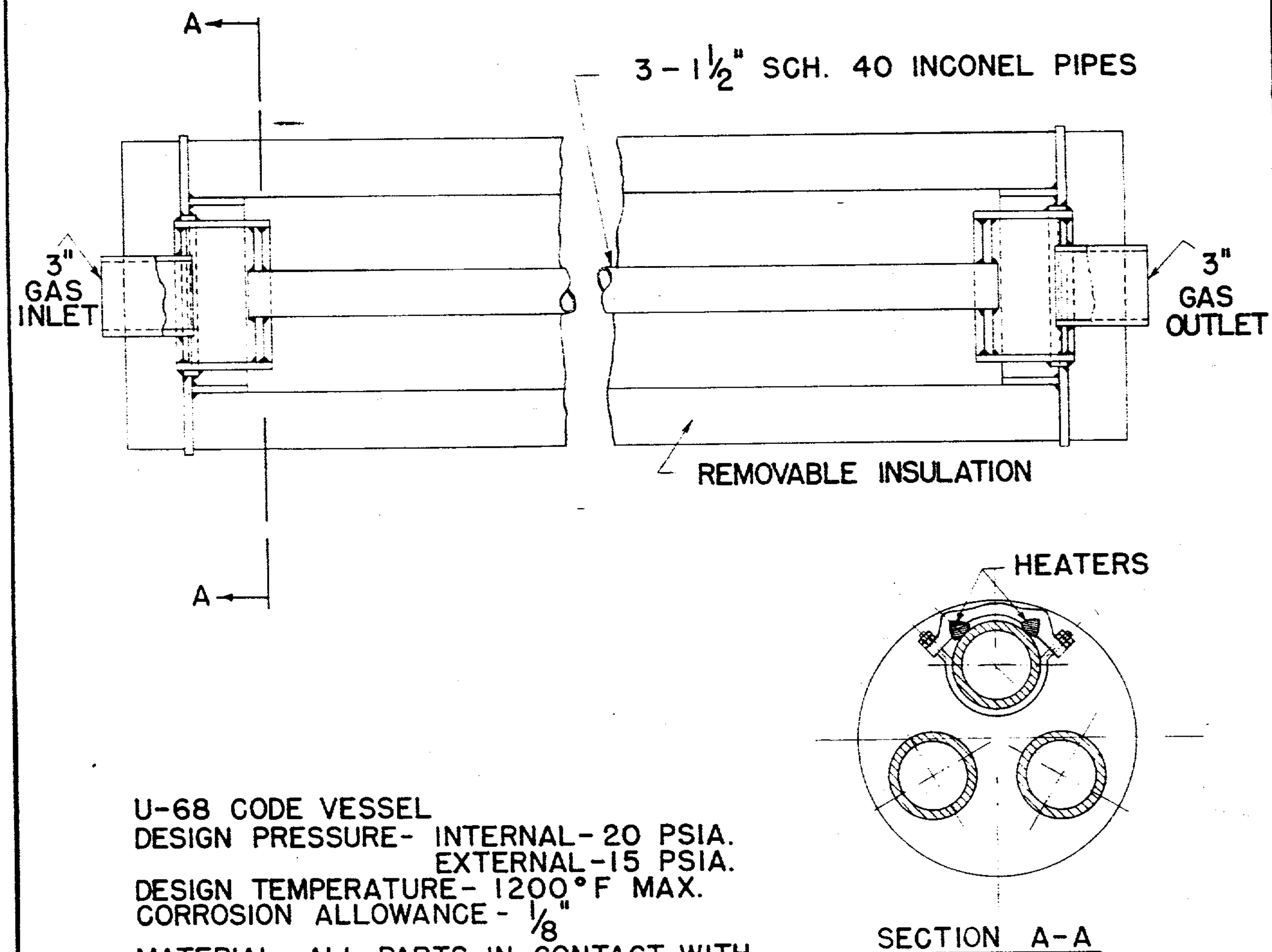
SYMBOL	SERVICE	
	H-4	F-1
A	OUTLET	OUTLET
B	INLET	INLET
C	INLET	INLET
E	INSPECTION OPENING	INSPECTION OPENING
F	INSPECTION OPENING	INSPECTION OPENING
G	———	INLET

REFERENCE DRAWINGS

INDUSTRIAL PROCESS ENGINEERS
8 LISTER AVENUE., NEWARK, N.J.
DWG. D-896-9 - REV. C., F-1
DWG. D-896-7 - REV. C., H-4

FIGURE 14

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
MIXING CHAMBERS (F-1, H-4)	
ENGINEER: R. M. Vail	APPV'D BY:
DRAFTSMAN: J. C. Elliott	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1286



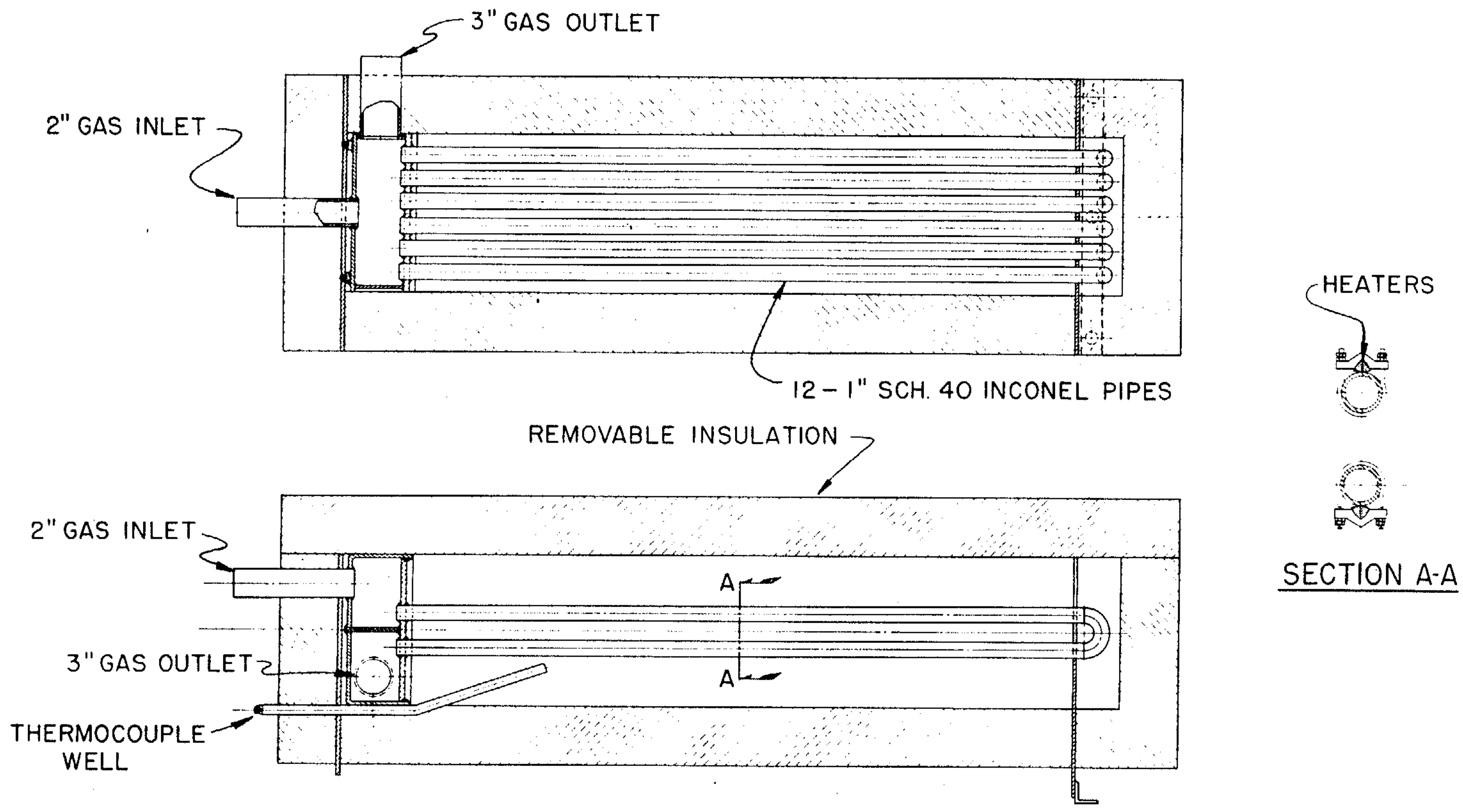
U-68 CODE VESSEL
DESIGN PRESSURE- INTERNAL-20 PSIA.
EXTERNAL-15 PSIA.
DESIGN TEMPERATURE- 1200°F MAX.
CORROSION ALLOWANCE - 1/8"
MATERIAL- ALL PARTS IN CONTACT WITH CONTENTS ARE INCONEL. ALL OTHER PARTS CARBON STEEL.
HEATERS-6 CHROMALOX HEATERS
TI 6015 XX-2500 WATTS @ 230 V.
55" LONG.
INSULATION- 2½" THICK UNIBESTOS IN REMOVABLE SECTIONS.

REFERENCE DRAWING

INDUSTRIAL PROCESS ENGINEERS
8 LISTER AVE. NEWARK, N.J.
DRAWING NO.- F-917-2 REV.-A

FIGURE 15

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
HF SUPERHEATER (H-3)	
ENGINEER: R.M. Vail	APPV'D BY:
DRAFTSMAN: R.M. Angevine	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1287



U-68 CODE VESSEL.
DESIGN PRESSURE ---- INTERNAL -- 20 p.s.i.a.
EXTERNAL -- 15 p.s.i.a.
DESIGN TEMPERATURE ---- 1200°F MAX.
CORROSION ALLOWANCE ---- $\frac{1}{8}$"
MATERIAL ---- ALL PARTS IN CONTACT WITH CONTENTS ARE INCONEL.
HEATERS ---- 12 CHROMALOX HEATERS NO. 6015XX 1200 WATTS @ 230 v., 4'-6" LONG.
INSULATION ---- $\frac{1}{2}$" OF SUPEREX AND $3\frac{1}{2}$" OF MAGNESIA IN REMOVABLE SECTIONS.

S-1288

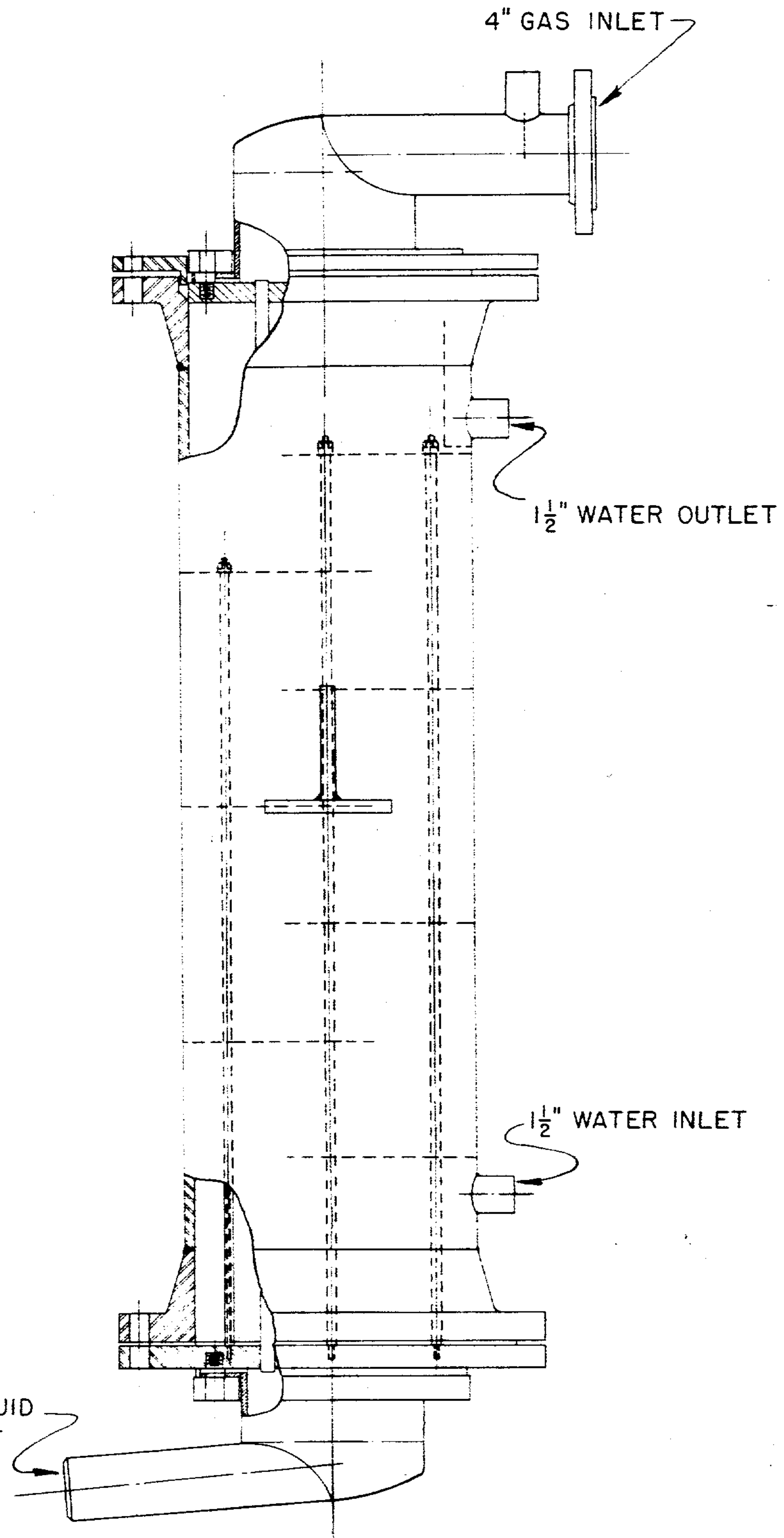
REFERENCE DRAWING

INDUSTRIAL PROCESS ENGINEERS
8 LISTER AVENUE NEWARK, N.J.

DWG. F-917-1, REV. A

FIGURE 16

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
HF PREHEATERS (H-5)	
ENGINEER: R. M. Vail	APP'V'D BY
DRAFTSMAN: [signature]	DATE 6-23-50
SCALE: NONE	DWG NO. S-1288



SINGLE PASS CONDENSER
U-68 CODE VESSEL
DESIGN TEMP ----900°F.
TEST PRESS. ----BOTH SIDES
HYDROSTATIC ----60 p.s.i.g.
AIR ----45 p.s.i.g.
EMPTY WEIGHT ----1520 lbs.
ALL METAL IN CONTACT WITH PROCESS FLUID IS MONEL.

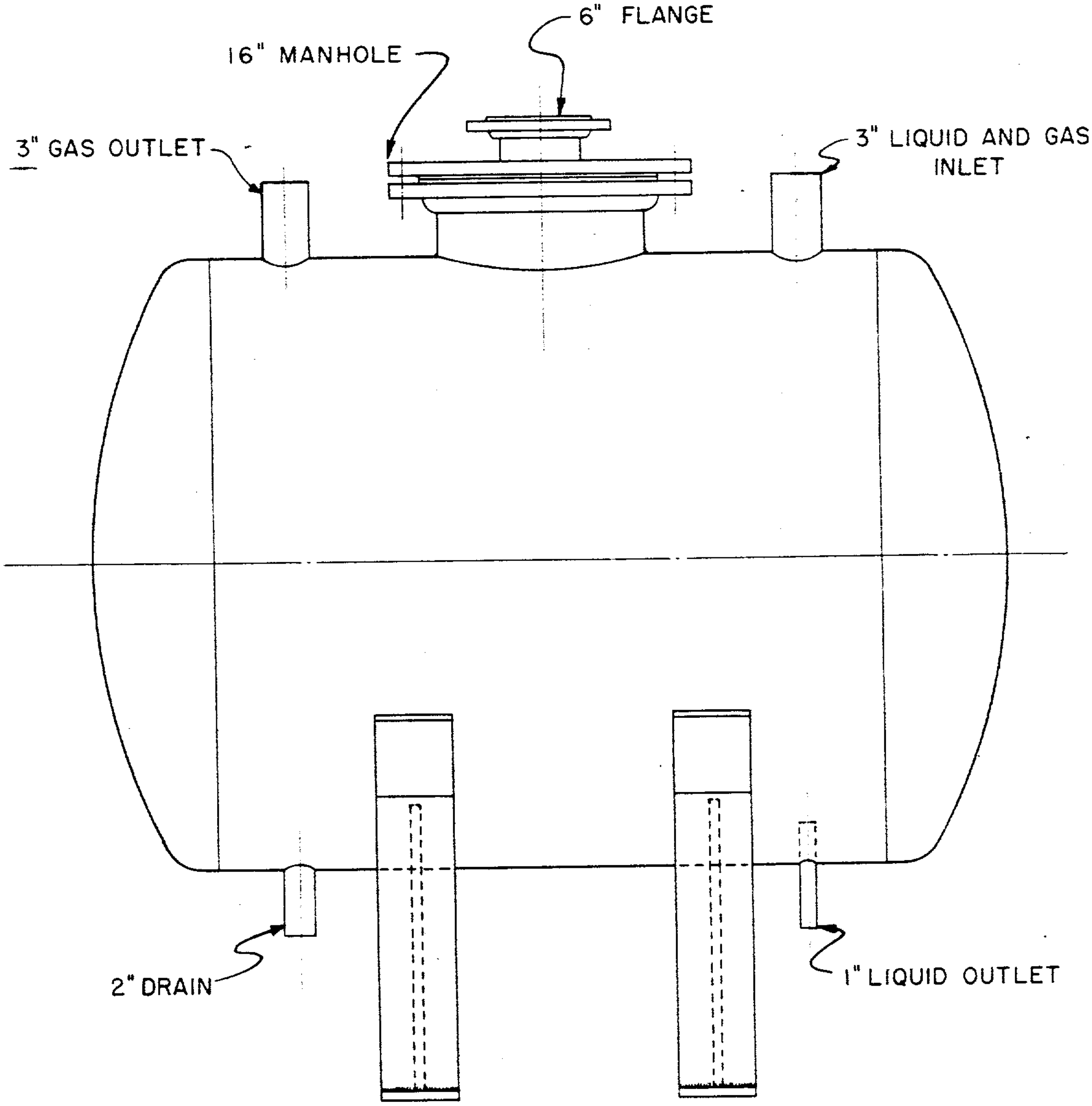
REFERENCE DRAWING

MATT. CORCORAN & CO.
LOUISVILLE, KY.

DWG. NO. 1553

FIGURE 17

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
PARTIAL CONDENSERS (H-7)	
ENGINEER: R. M. Vail	APPV'D BY:
DRAFTSMAN: J. C. Elliott	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1289



U-68 CODE VESSEL
DESIGN PRESS. ---- 15 p.s.i.g. EXT.
5 p.s.i.g. INT.
OPER. TEMP. ---- 180°F
CAPACITY ---- 500 GAL.
ALL PARTS IN CONTACT WITH CONTENTS ARE MONEL. ALL OTHER PARTS ARE CARBON STEEL.

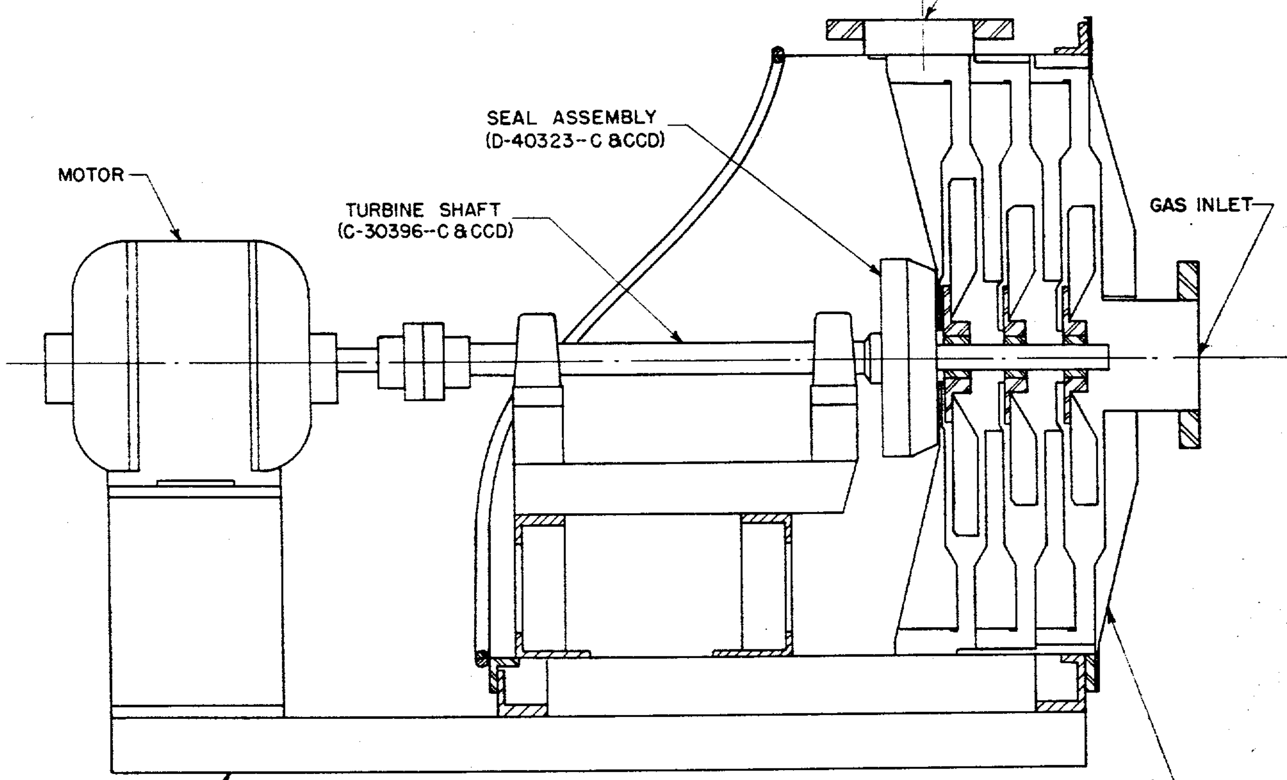
REFERENCE DRAWING

INDUSTRIAL PROCESS ENGINEERS
8 LISTER AVENUE., NEWARK, N.J.

DWG. F-896-8, REV. C.

FIGURE 18

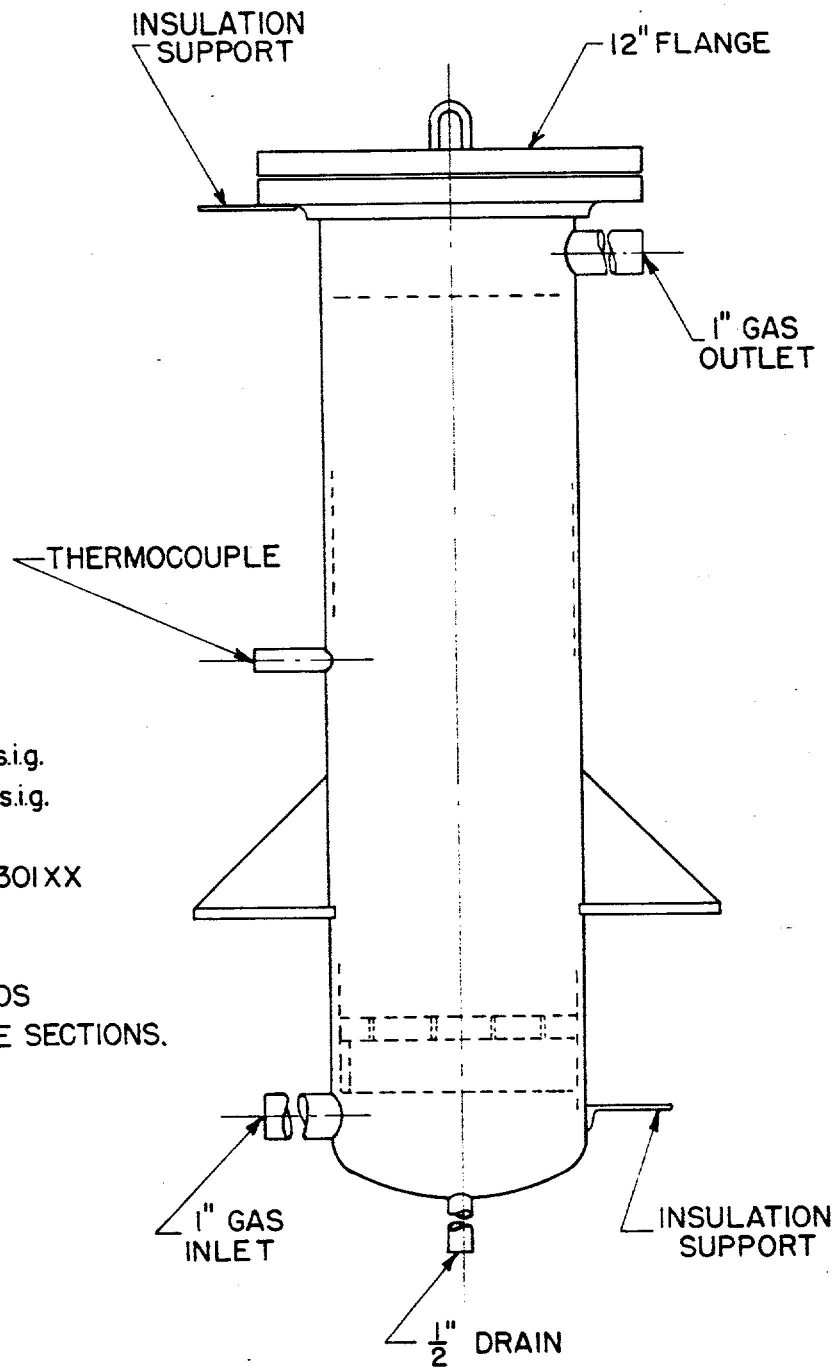
CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
HOLD TANK (H-9)	
ENGINEER: R.M. Vail	APPV'D BY:
DRAFTSMAN: [illegible]	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1290



REFERENCE DRAWING
THE SPENCER TURBINE CO.
HARTFORD, CONN.
DWG. B-11205

FIGURE 19

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
HF BLOWERS (H-12)	
ENGINEER: R. M. Vail	APPV'D BY:
DRAFTSMAN: R. T. Lovell	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1291



U-68 CODE VESSEL
MATERIAL – STEEL
DESIGN PRESS.– INTERNAL – 5 p.s.i.g.
EXTERNAL – 15 p.s.i.g.
DESIGN TEMP. – 600°F
HEATERS – 6 - CHROMALOX # SE 4301 XX
1500 w, 3 ϕ, 60~, 230 v

INSULATION – 3" THICK UNIBESTOS
BUILT IN REMOVABLE SECTIONS.

<u>REFERENCE DRAWING:</u>

INDUSTRIAL PROCESS ENGINEERS
8 LISTER AVE. NEWARK, N.J.
DWG. C-896-1 REV. B

FIGURE 20

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
NaF TRAPS (H-13, F-10)	
ENGINEER: R. M. Vail	APPV'D BY:
DRAFTSMAN: R. T. Lowell	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1292

MATERIAL ---- MONEL
PACKING ---- $\frac{1}{2}$" MONEL RASCHIG RINGS.
DESIGN PRESSURE ---- 5 p.s.i.g. INTERNAL.
15 p.s.i.g. EXTERNAL.
DESIGN TEMPERATURE ---- 230°F
CORROSION ALLOWANCE ---- $\frac{1}{8}$"
HEATERS: 6-1000 WATT 5'-0" LG. CHROMALOX HEATERS AROUND EACH OF TWO COLUMN SECTIONS. (12 IN ALL)
24-2500 WATT 30$\frac{1}{2}$" LG. AROUND STILL POT.
ALL HEATERS ARE 3ϕ, 60~, 230 v.
INSULATION: ---- 3" THICK ROCK-WOOL BLANKET IN REMOVABLE SECTIONS.

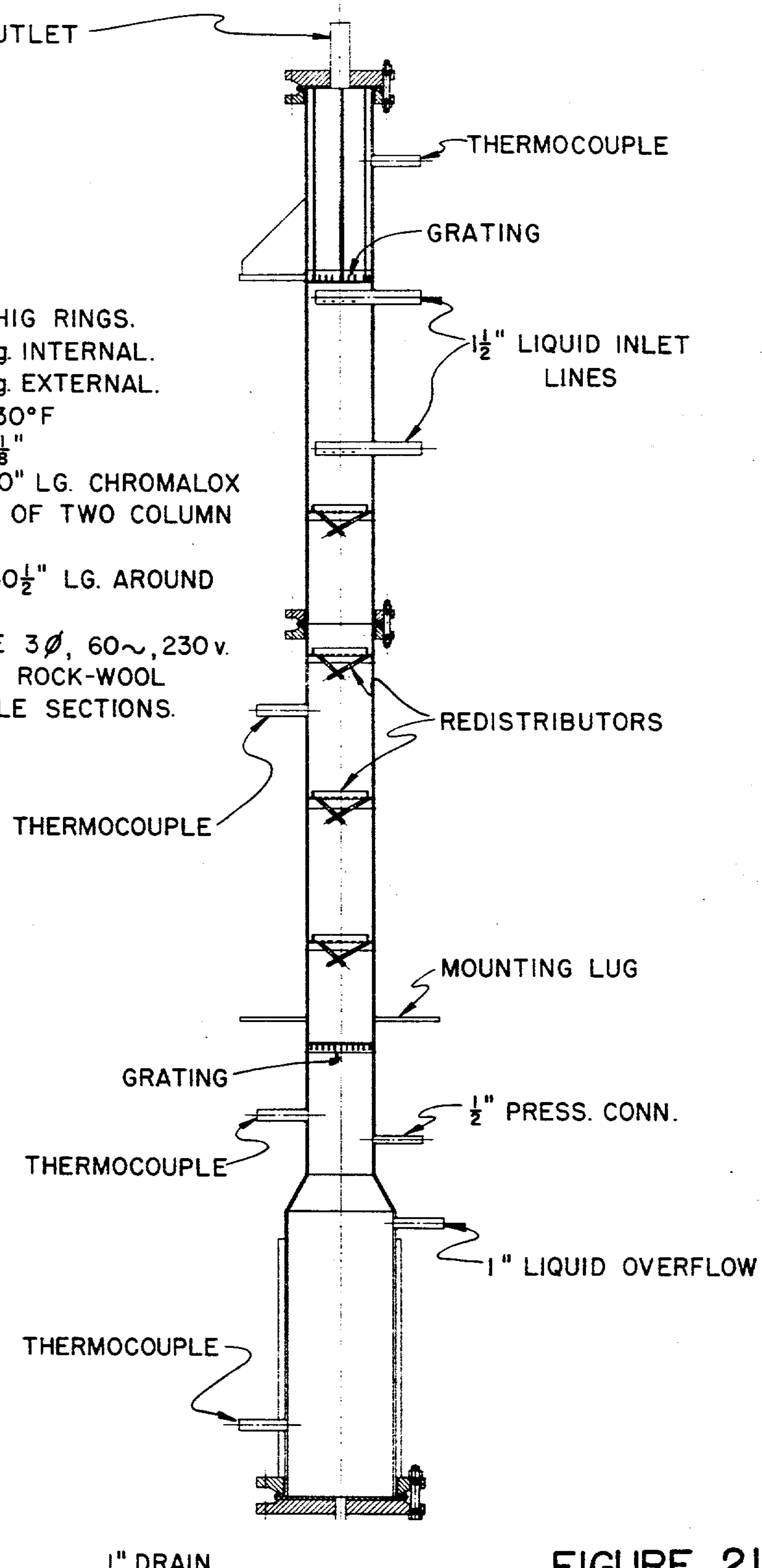
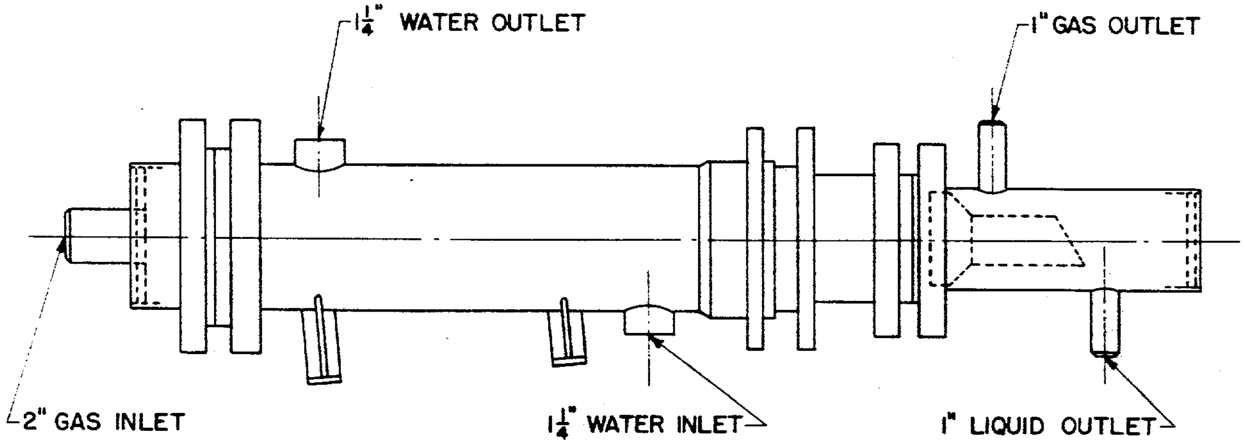


FIGURE 21

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
HF STILL (H-10)	
ENGINEER: R. M. Vail	APPV'D BY:
DRAFTSMAN: J. C. Elliott	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1293

REFERENCE DRAWING

INDUSTRIAL PROCESS ENGINEERS
8 LISTER AVENUE., NEWARK, N.J.
DRAWING F-896-5 REV. B



SINGLE PASS TUBE, SINGLE PASS SHELL CONDENSER
U-68 CODE VESSEL – WEIGHT – EMPTY-415 LBS. – FLOODED-465 LBS.

	SHELL	TUBES
MATERIAL	STEEL	MONEL
DESIGN PRESS.	50 p.s.i.g.	5 p.s.i.g. & VAC
DESIGN TEMP.	200 °F	300 °F
HYDROSTATIC TEST	100 p.s.i.g.	25 p.s.i.g.
CORROSION ALLOWANCE	$\frac{1}{8}$"	$\frac{1}{8}$"

REFERENCE DRAWING:

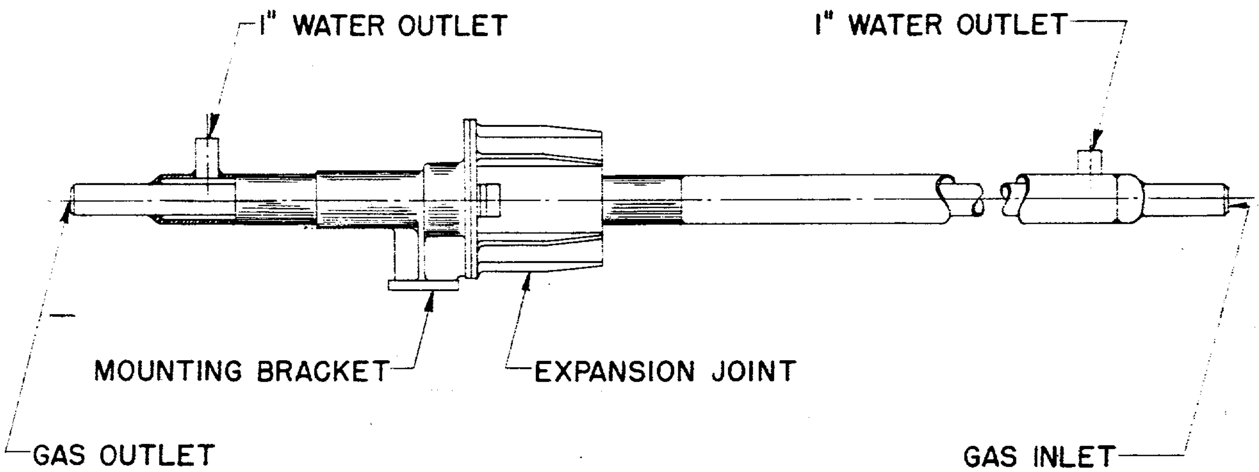
THE WHITLOCK MFG. CO.
HARTFORD, CONN.
DWG. A-14559 REV. 1

FIGURE 22

CARBIDE AND CARBON CHEMICALS DIVISION
K-25 ENGINEERING DEVELOPMENT DIVISION

REFLUX CONDENSER (H-11)

ENGINEER: R. M. Vail	APPV'D BY:
DRAFTSMAN: R. T. Lovell	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1294



	AZEOTROPE COOLER	SECONDARY COOLER
U-68 CODE VESSEL	YES	YES
MATERIAL	MONEL	MONEL
DESIGN	5 psig INT.	5 psig INT.
	15 psig EXT.	15 psig EXT.
DESIGN TEMPERATURE	230° F.	950° F.

REFERENCE DRAWINGS

CARBIDE & CARBON CHEMICALS DIV.

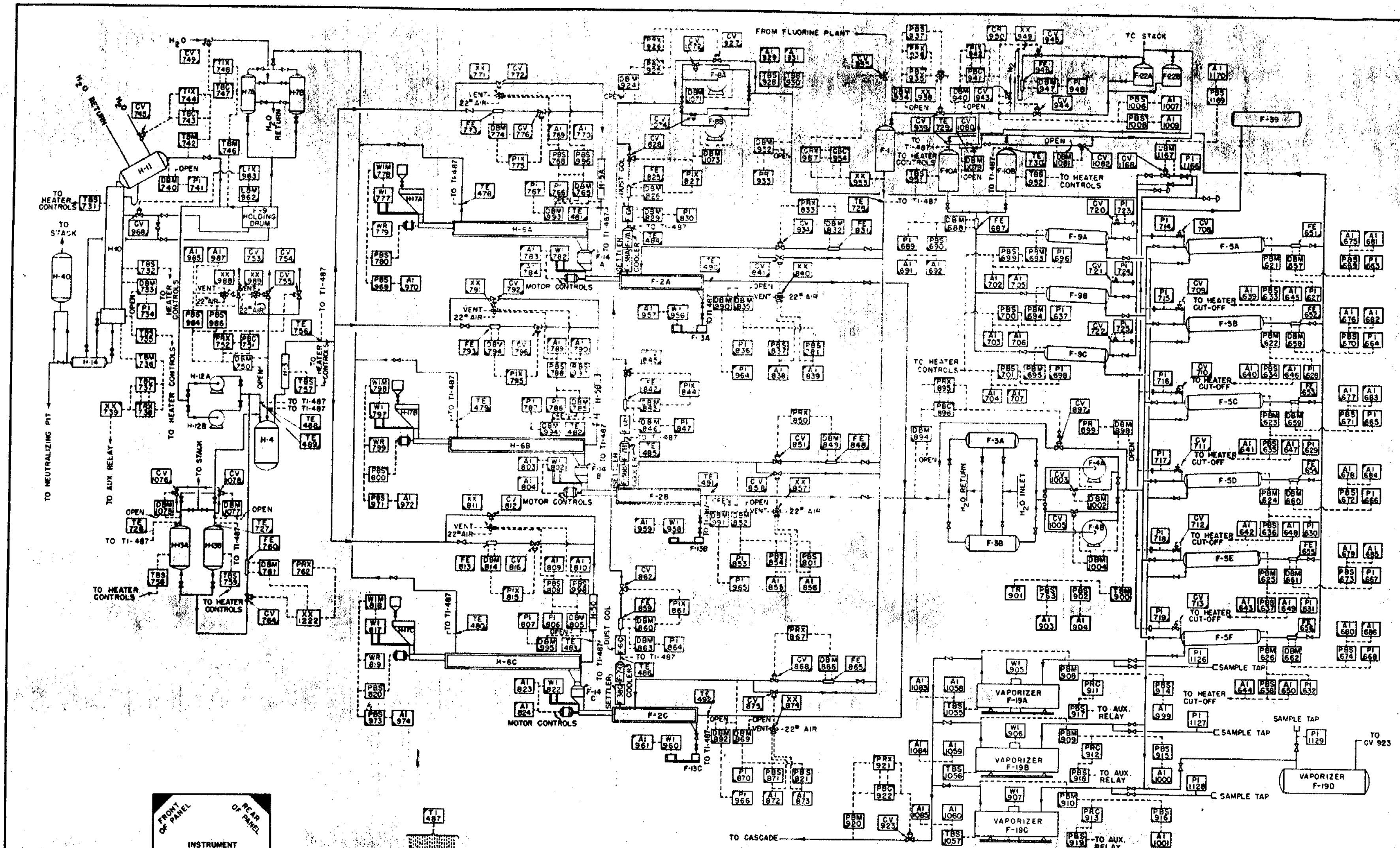
OAK RIDGE, TENNESSEE

B-AWP-11543-3 (H-14)

B-AWP-11544-2 (F-7A-C)

FIGURE 23

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
AZEOTROPE & SECONDARY COOLERS (H-14, F-7)	
ENGINEER: R.M. Vail	APPV'D BY:
DRAFTSMAN: JJ Tudor	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1295



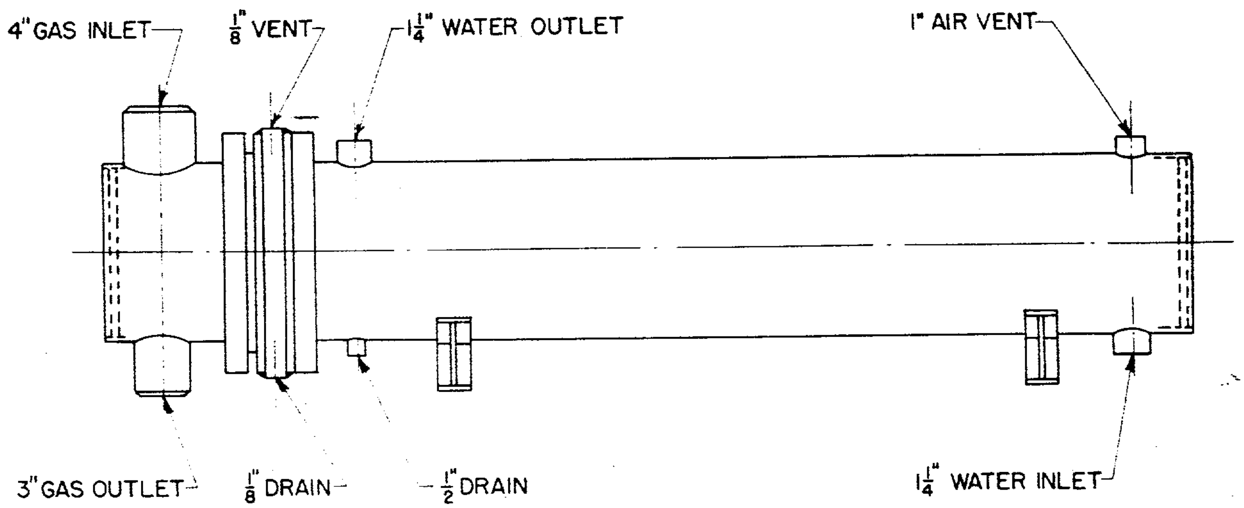
NOTE:

1. SEE FIGURE 12 FOR AUXILIARY INSTRUMENTATION, AND TEMPERATURE INSTRUMENTATION ON TRAY REACTORS AND COLD TRAPS.

2. SEE "INSTRUMENT APPLICATION TABULATION 1131 SECTION" FOR SPECIFICATIONS AND SERVICE.

FIGURE 24

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
INSTRUMENT APPLICATION DIAGRAM	
ENGINEER: R. M. Vail	APPV'D BY:
DRAFTSMAN: R. M. Angerine	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1296



HAIRPIN TYPE COOLER – GAS ON TUBE SIDE
AREA – 674 SQ. FT. U-68 CODE VESSEL
WEIGHT - EMPTY - 700 LBS - FLOODED - 900 LBS.

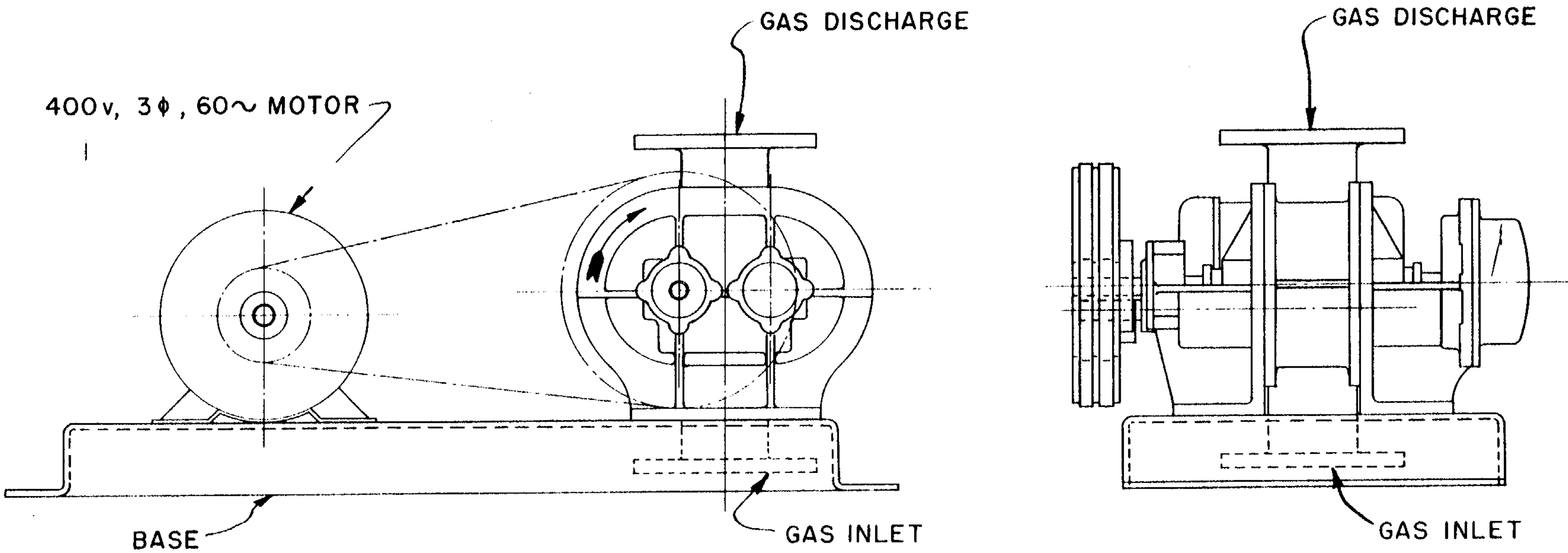
	SHELL	TUBES
MATERIAL	STEEL	MONEL
DESIGN PRESS.	50 p.s.i.g.	5 p.s.i.g. & VAC
DESIGN TEMP.	200° F	900° F
HYDROSTATIC TEST	100 p.s.i.g.	25 p.s.i.g.
CORROSION ALLOWANCE	1/8"	1/8"

REFERENCE DRAWING:

THE WHITLOCK MFG. CO.
HARTFORD, CONN.
DWG. A-14560 REV. 1

FIGURE 25

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
PRIMARY COOLERS (F-3 A-C)	
ENGINEER: R. M. Vail	APPV'D BY:
DRAFTSMAN: R. T. Lowell	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1297



	PRIMARY COMPRESSORS	SECONDARY COMPRESSORS
MATERIAL.	MONEL	MONEL
SUCTION PRESS.	0 p.s.i.g.	0 p.s.i.g.
DISCHARGE PRESS.	2 p.s.i.g.	2 p.s.i.g.
DESIGN TEMP.	150°F	150°F
MAX. VOLUME.	100 CFM	20 CFM
MAX. SEAL INLEAKAGE.	0.1 CFM	0.1 CFM

REFERENCE DRAWINGS

ROOTS CONNERSVILLE BLOWER CORP.
CONNERSVILLE, INDIANA

DWG. 2D5687, PRINT NO. 5221, (F-8)
DWG. 2D5696, PRINT NO. 5220, (F-4)

FIGURE 26

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
F_2 COMPRESSORS (F-4, F-8)	
ENGINEER: R.M. Sail	APPV'D BY:
DRAFTSMAN: J.C. Elliott	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1298

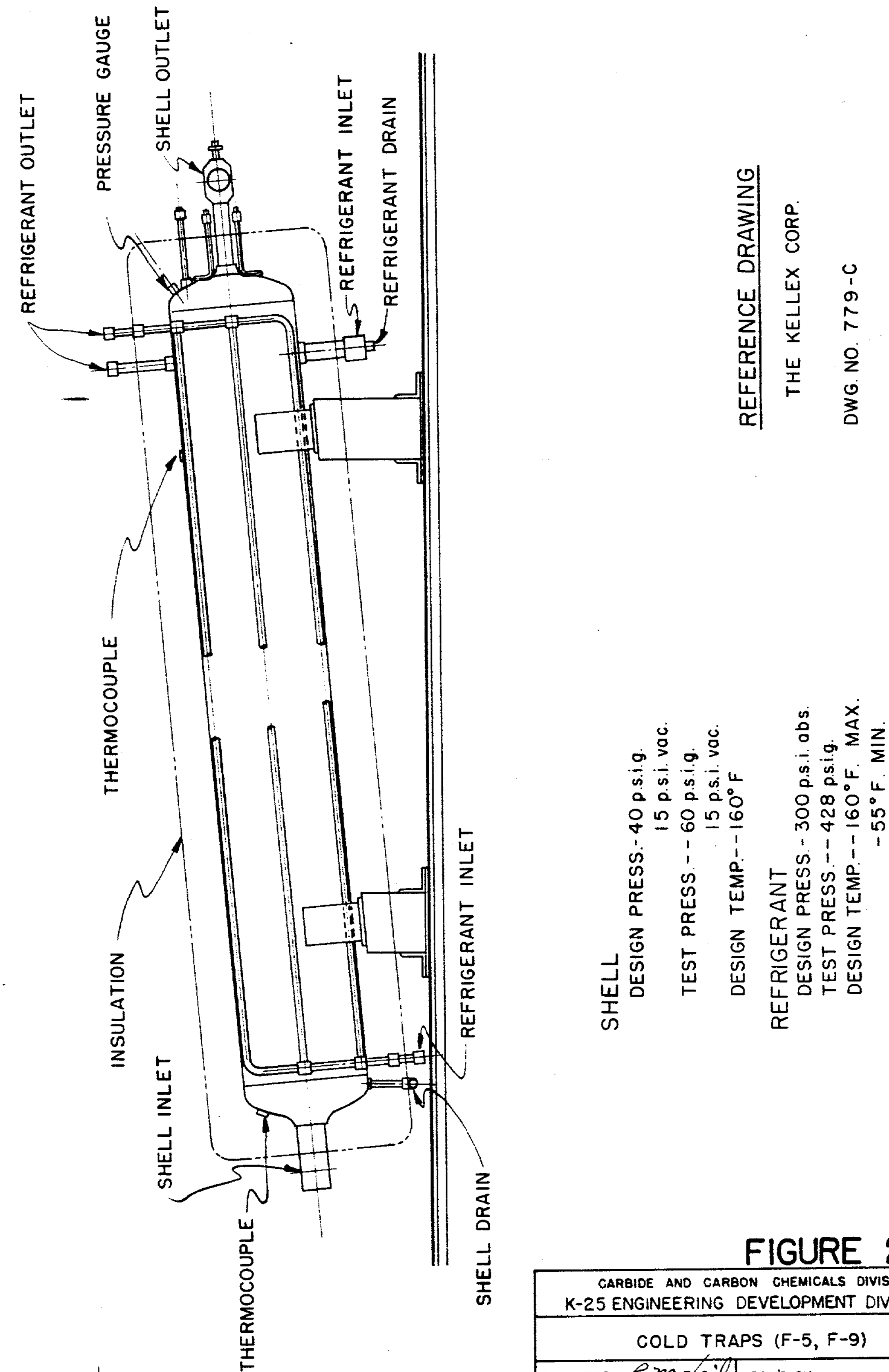
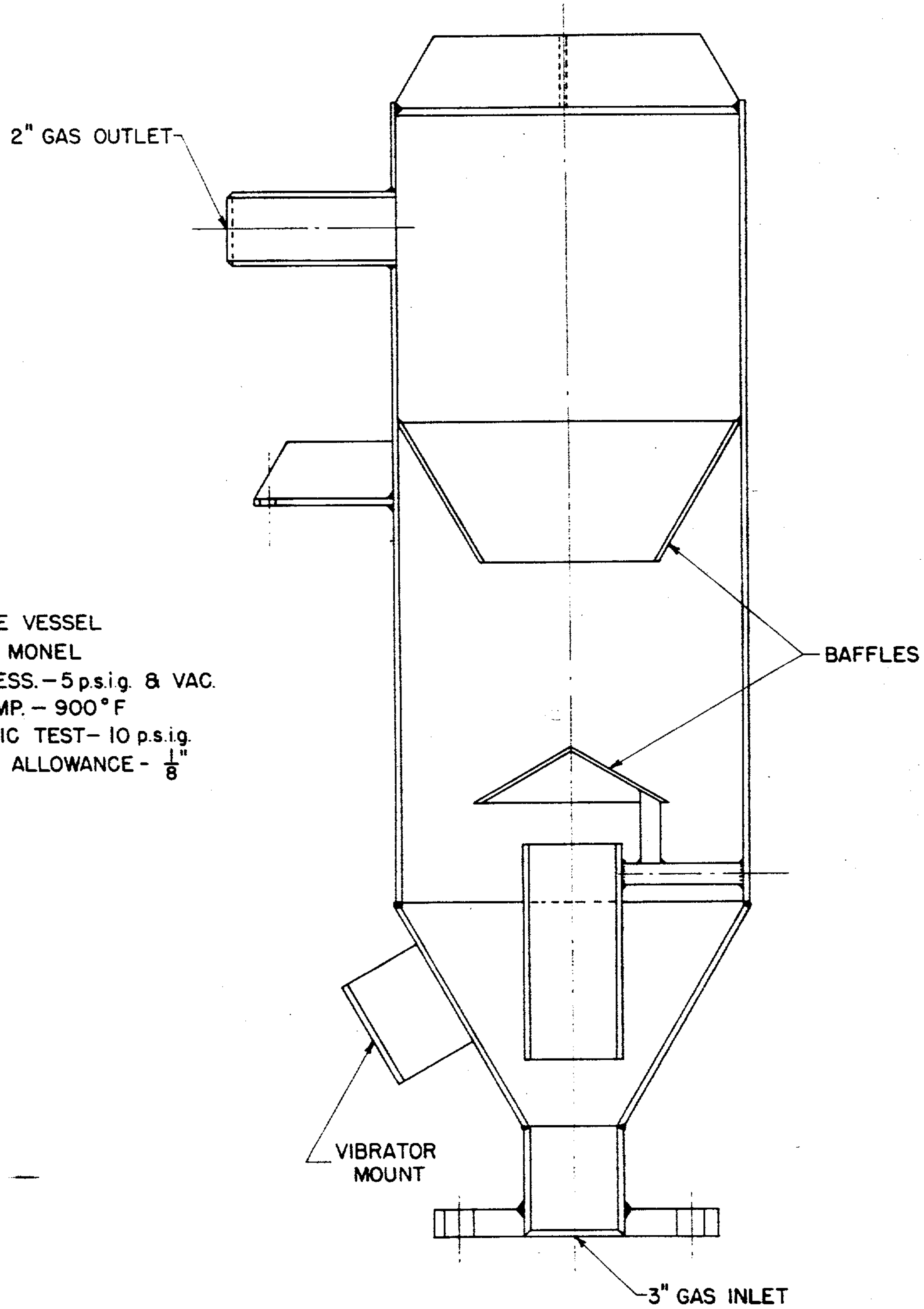


FIGURE 27

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
COLD TRAPS (F-5, F-9)	
ENGINEER: R.M. Vail	APPV'D BY:
DRAFTSMAN: J.C. Elliott	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1299

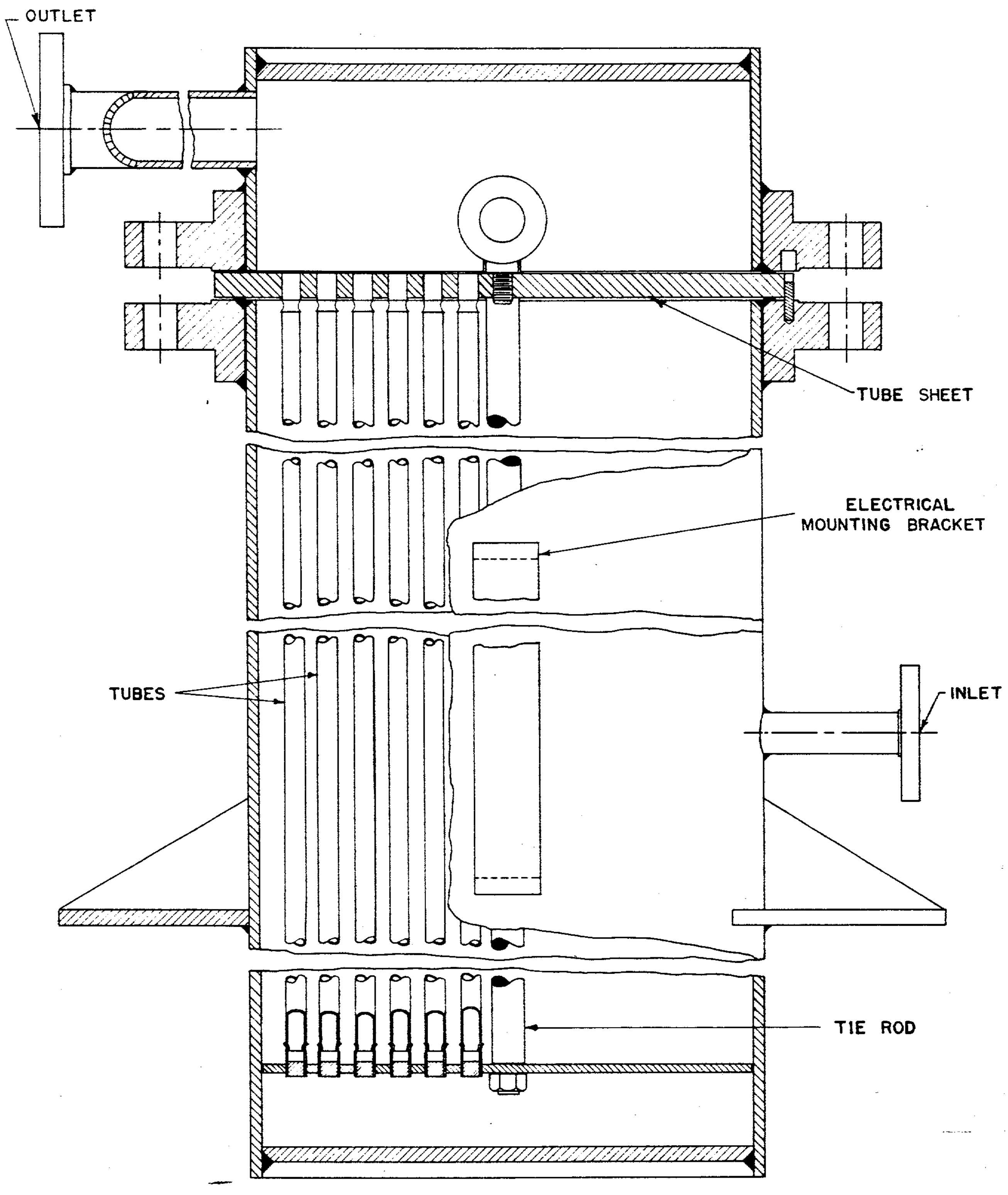


U-69 CODE VESSEL
MATERIAL - MONEL
DESIGN PRESS. – 5 p.s.i.g. & VAC.
DESIGN TEMP. – 900°F
HYDROSTATIC TEST – 10 p.s.i.g.
CORROSION ALLOWANCE - $\frac{1}{8}$"

FIGURE 28

REFERENCE DRAWING:
NOOTER CORPORATION
ST. LOUIS 4, MISSOURI
DWG. JN-C 6296 REV. A

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
DUST SEPARATOR (F-38)	
ENGINEER: R. M. Vail	APPV'D BY:
DRAFTSMAN: R. T. Lowell	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1300



DRAWING NO. ------ C. & C.C. D. - D-40287-2
OPERATING PRESSURE--------- 0-18 PSIA.
HYDROSTATIC TEST PRESSURE--- 30 PSIG.

6 CALROD HEATERS, 10'-0" LONG, 300 W, 230 V.
STEEL SHEATH.
INSULATION -- 1" 85 % MAGNESIA.
MATERIAL -- NICKEL PLATED STEEL.

FIGURE 29

CARBIDE AND CARBON CHEMICALS DIVISION
K-25 ENGINEERING DEVELOPMENT DIVISION

DUST FILTER (F-6)

ENGINEER: R.M. Vail	APPV'D BY:
DRAFTSMAN: R.M. Angerine	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1301

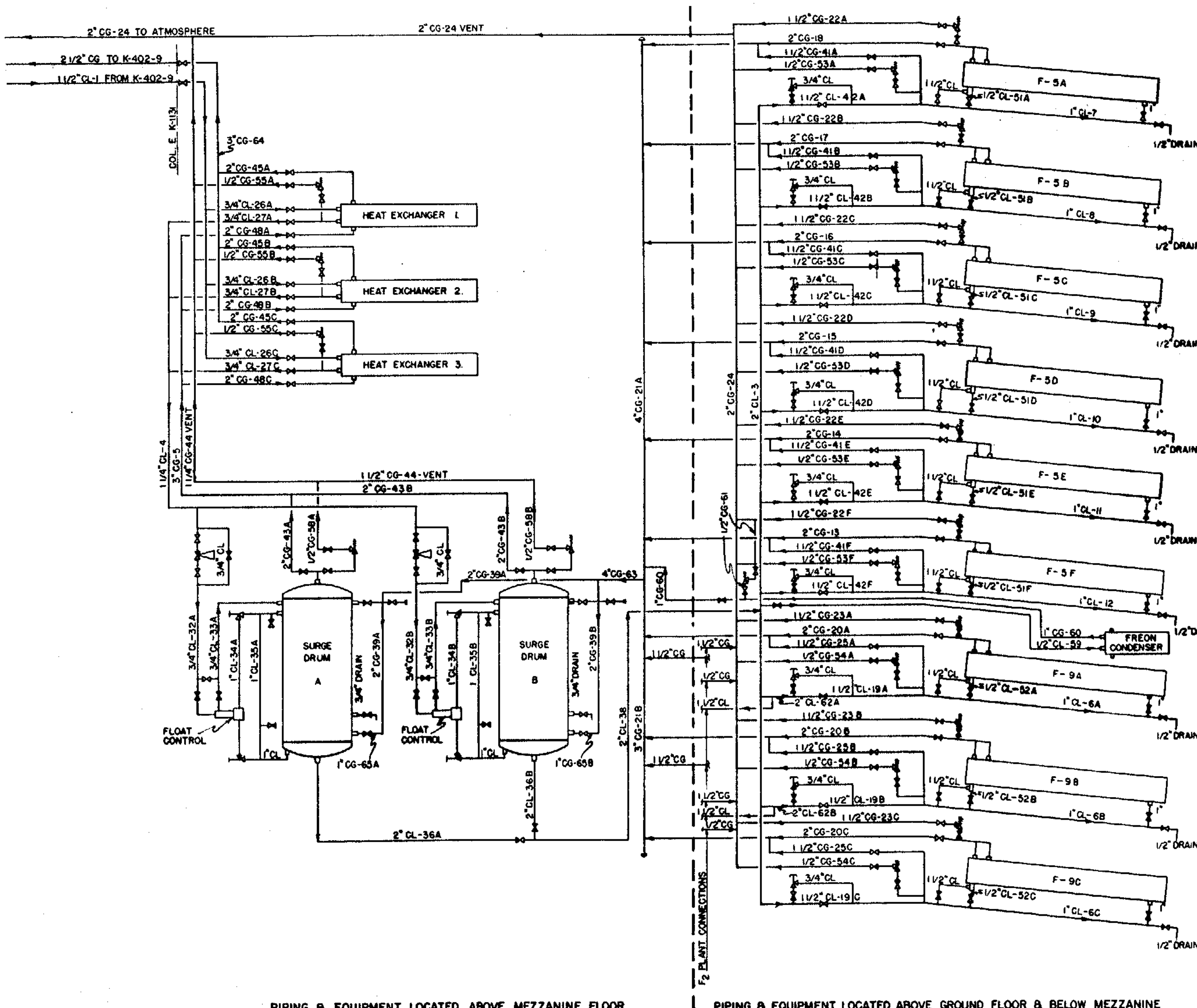


FIGURE 30

CARBIDE AND CARBON CHEMICALS DIVISION
K-25 ENGINEERING DEVELOPMENT DIVISION

CO_2 FLOW DIAGRAM

ENGINEER: R.M. Vail	APPV'D BY:
DRAFTSMAN: R.T. Powell	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1302

70

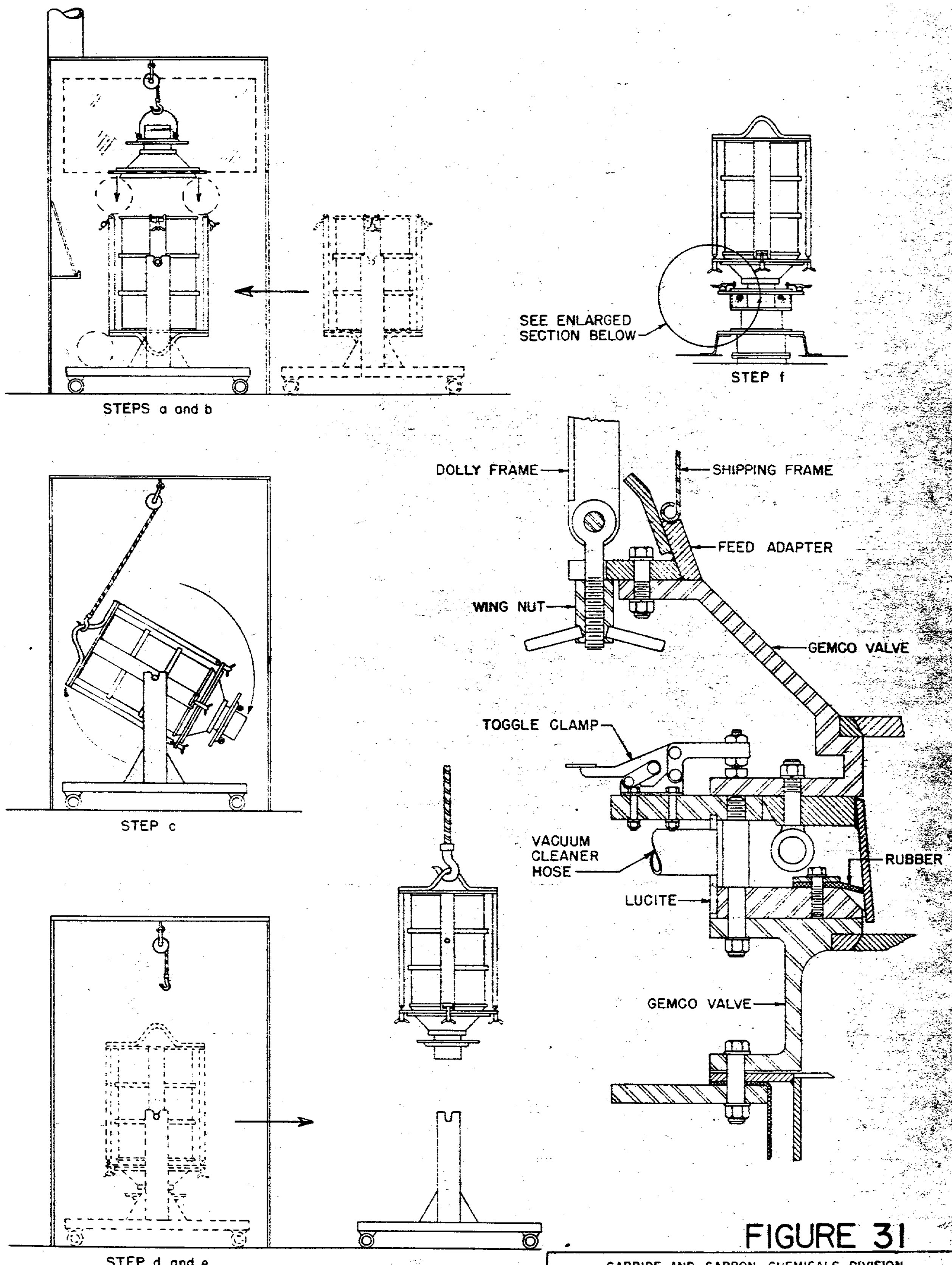
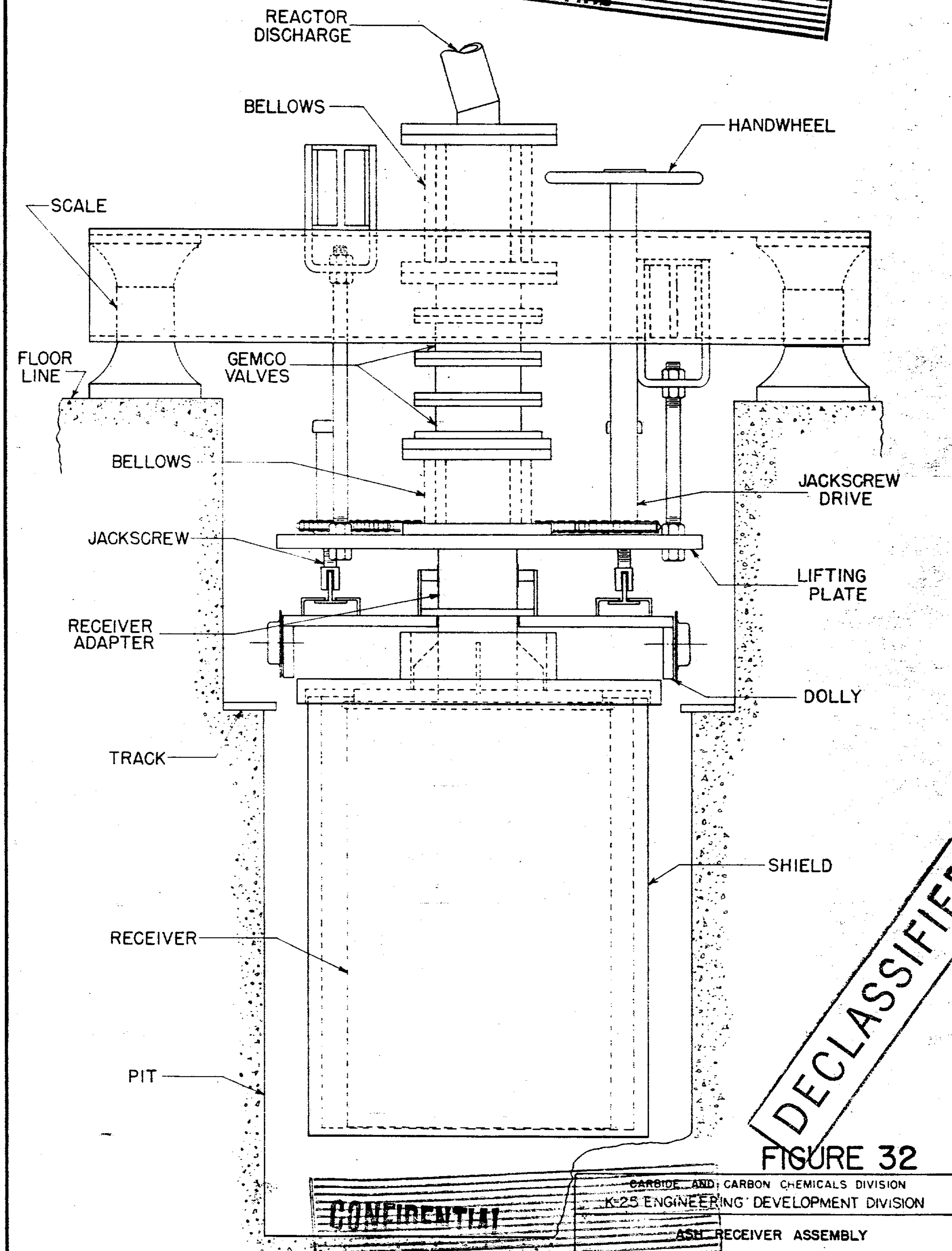


FIGURE 31

CARBIDE AND CARBON CHEMICALS DIVISION K-25 ENGINEERING DEVELOPMENT DIVISION	
UO_2 TRANSFER SYSTEM	
ENGINEER: RMVail	APPV'D BY:
DRAFTSMAN: R. T. Lovell	DATE: 6-23-50
SCALE: NONE	DWG. NO. S-1313

SECRET
CONFIDENTIAL



DECLASSIFIED

FIGURE 32

CARBIDE AND CARBON CHEMICALS DIVISION
K-25 ENGINEERING DEVELOPMENT DIVISION

ASH RECEIVER ASSEMBLY

ENGINEER: K.M. Vail	APPV'D BY:
DRAFTSMAN: R.T. Lovell	DATE: 6-23-50
SCALE: NONE	DWG. NO. SI-1314

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SECRET

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